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A multivariate study of cranial variation in middle and upper Pleistocene human populations

A MULTIVARIATE STUDY OF CRANIAL VARIATION IN MIDDLE AND UPPER PLEISTOCENE HUMAN POPULATIONS

BY

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MEMORANDUM

The work described in this thesis was the original and unaided work of the author. No part of this dissertation has been submitted for any other degree from the University of Bristol, or to any other university.

C.B. Stringer

(C.B. Stringer)

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CHAPTER ONE: INTRODUCTION

(i) Introductory remarks

From the time of the first Neanderthal discovery (Fuhlrott, 1857) in the Neander Valley near Dusseldorf, the evolutionary position of this group of fossil men has been a source of much debate among anthropologists. Even though many more remains of Pleistocene man have since been discovered in Europe and elsewhere, the picture of the later stages of human evolution has not been clarified. This has been partly due to the fragmentary nature of the fossils themselves or to doubt about their true antiquity, but much of the dispute has stemmed from the failure of anthropologists to employ standardised measurements, to define many terms such as "Neanderthal" properly, or even to adequately compare new fossils with others already discovered before assigning meaningful taxonomic names.

In 1970 the present author embarked on the study described here, with the aim of examining the available fossil cranial material from the Middle and Upper Pleistocene and attempting to quantify the extent of variation found in the fossils themselves compared to that found in recent populations. The system of measurements chosen was that used by Howells in an extensive multivariate study of cranial variation in modern man (Howells, 1973), and the main method of analysing the data was Mahanolobis's generalised distance (D^2) statistic. Van Vark (1970) stated that if "an electronic computer is available, there are no decisive arguments in favour of using any other measure than Mahanolobis's D^2 for the determination of morphological differences between populations". Nevertheless this statistic has been only rarely employed in previous

craniometric studies. It was hoped that application of this measure would give a realistic estimate of the degree of variability found in Pleistocene fossil human crania compared with that found today, and that it would clarify the relationships of problematic fossils.

In the rest of this chapter the author will attempt to critically examine the main theories concerning Middle and Upper Pleistocene human evolution, primarily using the position of the "classic" Neanderthals of the European Würm as a means of classifying the various schemes described. Throughout this thesis the author will use the original spelling of "Neanderthal". Vallois (1952) pointed out that although the specific designation "Homo neanderthalensis" could retain the original spelling, it might be more correct to follow orthographic changes in German and use the spelling "Neandertal" in other cases. Howell adopted this idea in 1951, but subsequently reverted in several publications to the older spelling (Howell, 1957, 1960, 1970). Since few other anthropologists have taken up Vallois' suggestion, the older spelling will be used in preference here.

(ii) Theories excluding the Neanderthals or related forms from the ancestry of modern man

Marcelin Boule has been one of the most influential anthropologists of this century. He produced detailed studies of the most famous Neanderthal skeleton - that of La Chapelle-aux-Saints (Boule, 1911-1913) which became the "type" specimen of the group and against which most later discoveries have been primarily compared. His views on human evolution have influenced many workers, including some still writing today (for a fuller examination of this subject see Brace, 1964).

Boule's ideas were gained from his previous experience in palaeontology and he viewed primate evolution as comparable to a tree with branches, branchlets and twigs; some of them remained static before dying, others produced types which had a brief ascendancy and were then replaced by more vigorous shoots. Hence he said of Neanderthal man "he represents a peculiar species, the terminal bloom of a twig, now withered and dead, of the human branch" (Boule, 1923). Even more ancient types such as "Pithecanthropus" were not to be regarded as part of man's evolutionary history, but were anthropoids which had gained some hominid features by convergent evolution and had then become extinct.

Boule's study of the first reasonably complete Neanderthal skeleton led him to reject the Neanderthals as possible forebears of later man. To him they were "a belated type existing side by side with the direct ancestors of Homo sapiens" (Boule, 1923) in a relationship like that of the "inferior" and "superior" races of modern man. They were in fact a degenerate group retaining many

simian traits from the distant past, but also showing specialisations of their own. The features setting Neanderthal man apart from Homo sapiens have been described in great detail by Boule, although many of the supposedly unusual characteristics, especially those of the post-cranial skeleton of La Chapelle, are now accredited to pathological changes or inadequate comparison with a sufficiently wide range of modern comparative material (Morton, 1926; Arambourg, 1955; Patte, 1955; Straus and Cave, 1957; Stewart, 1962; Brace, 1964).

Boule in fact did not allow himself to be greatly misled by the Piltdown skull, now known to be a forgery (Weiner, Oakley and Le Gros Clark 1953), nor by many of the claimed "sapiens" fossils of great antiquity. But he was sure of the sudden appearance of modern man in Europe and he believed that the Aurignacians swept in fully evolved from elsewhere with a minimum amount of contact with the "inferior" Neanderthals. Such a highly developed form and culture as that of the Aurignacians must, in his opinion, have required a long and separate evolutionary history from that of the Neanderthals.

Less cautious than Boule in his attitude to the Piltdown remains and supposedly ancient sapiens fossils, Sir Arthur Keith held a similar position of great esteem amongst British anthropologists. Like Boule he believed that the modern and Neanderthal lineages had been separated from a very ancient period. Using dates for the duration of the Pleistocene much smaller than those assumed today, Keith could only say that the common ancestor of modern races must have reached a much higher stage by the close of the Pliocene period than that represented by "Pithecanthropus" (Keith, 1920). He asked "are we quite certain the

modern type may not be as old - in point of evolution - as the Neanderthal? That I think we must admit, and with that admission we must also grant the possibility of the discoveries at Galley Hill, at Clichy, and at Olmo as true" (Keith, 1920). In the same book Keith confidently asserted "the one thing we are now certain of is that he [Neanderthal man] was not suddenly converted into the modern type of man."

However through his study of the Mount Carmel remains (McCown and Keith, 1939) and the shrinking evidence for ancient "sapiens" fossils, Keith gradually modified his earlier views. By 1948, although still denying the evolution of Neanderthal man into modern man in Europe, he accepted that "after all Neanderthal man was the ancestor of the proud Caucasian". He also stated "I have had to abandon the claims of the modern type of man to a high antiquity, the very thesis which I set out to prove so long ago." Instead he took up the ideas of Weidenreich that the modern races of man had evolved from sub-species of Homo erectus, but in fact postulated much greater independence for each line and a greater degree of parallel evolution (Keith, 1948).

Vallois is the most famous exponent of the "pre-sapiens" theory alive today. His views on the place of Neanderthal man in human evolution were developed partly through the teaching of Boule and partly by his own studies of French fossil material. Like Boule he believed that whilst some features of the Neanderthals were to be regarded as intermediate between earlier and later hominids, many other were specialised and even "ultra-human". The Neanderthals were a homogenous group, quite distinct from

the early Aurignacians of Combe Capelle and Grimaldi. Furthermore these early Upper Palaeolithic fossils did not really exhibit primitive characteristics as claimed by Hrdlička (Hrdlička, 1927, 1930). Vallois summarised his views as follows:- "Our Aurignacians originate, then, in another line which, over a period of indefinite duration, developed parallel to Neanderthal man; it is to this line that the name of Praesapiens is conventionally given" (Vallois, 1954).

Although many of the remains previously put forward as early specimens of modern Homo sapiens were dismissed by him (Vallois and Movius, 1952; Vallois, 1954), the undisputed "Praesapiens" to Vallois were represented by the Swanscombe and Fontéchevade remains. His definition of the morphological characters of this group are as follows:-"Skull very thick with a low vault, mesocranial and doubtless also chamaecranial and tapeinocranial. Biasterionic breadth both absolutely and relatively large. Forehead upright and completely lacking any torus. Parietal of Homo sapiens type but with unobtrusive prominences. No parietal foramina and a primitive arrangement of the parieto-temporal articulation. Occipital little incurved vertically and without the characteristic "bun" of the Neanderthals. Cranial capacity probably voluminous" (Vallois, 1954). One of the crucial diagnostic features of Vallois' "Praesapiens" group is the absence of the supraorbital torus, but the Fontéchevade F.1. frontal fragment is the only specimen where this region is preserved. According to Vallois the individual was clearly adult (Vallois 1949, 1954, 1958) although others have disputed this claim (Brace, 1964) or advised caution

(Trinkaus, 1973).

Vallois has compared the morphology of European Homo sapiens, the "Praesapiens" and Homo neanderthalensis in nine features, and even from his own table (Vallois, 1954 p. 16) it is doubtful whether the "Praesapiens" are any more similar to the modern forms than to the Neanderthals. They resemble modern Homo sapiens in three characteristics, the Neanderthals in three characteristics, and both groups in two characteristics. Nevertheless Vallois suggested that the Neanderthal and "Praesapiens" lines had split at least by the Middle Pleistocene since the differences between Swanscombe and Steinheim were already marked. To him the "Praesapiens" are "the tangible evidence of the great antiquity of the phylum that culminates in modern man" (Vallois, 1954).

Other anthropologists have followed Vallois' arguments closely. For example Heberer believed that "a line leading to typical Homo sapiens can be traced far back into the Pleistocene without postulating the Neanderthalians as ancestors, even in their early form of the last interglacial, the Pre-Neanderthalians" (Heberer, 1959).

American anthropologists were influenced on the one hand by Hrdlička and Weidenreich, and on the other by Boule and Keith. Hooton and Montagu accepted Keith's work on Piltdown (Keith, 1920; 1939) which was in a way supported by his descriptions of the Swanscombe discovery. Thus Hooton and Montagu envisaged a line of "prato-humans" like "Eoanthropus", Galley Hill and Swanscombe without supraorbital tori, evolving into modern man. But they

also accepted that the Neanderthal genus included both "classic" and "progressive" types, and that the latter form could, through fossils such as Steinheim and Ehringsdorf, have also produced an archaic variety of Homo sapiens (Hooton, 1946; Montagu, 1947). The modern types of man, in Hooton's view, were actually the result of hybridisation between two separate lines produced by a remarkable convergent evolution (Hooton, 1946).

Louis Leakey was one of the most prolific discoverers of fossil men, and his own excavations increasingly strengthened his belief in the ancient origin of Homo sapiens. Initially his work on the Kanjera remains and the Kanam mandible led him to postulate that modern man was of at least Middle Pleistocene age (Leakey 1935, 1936). The Neanderthal type was "the product of over-specialisation away from the common stem which gave rise to Homo sapiens" and this applied equally to other hominids such as Rhodesian man and Homo erectus (Leakey 1953). Several remarkable discoveries from Olduvai Gorge and elsewhere confirmed the plausibility of his evolutionary scheme and he believed that at least three stocks were represented in the Olduvai deposits. One was an Australopithecine line which became extinct. Another was a "proto-erectus" line leading to Homo erectus; and the third line, with an antiquity of over two million years, led from Homo habilis to Homo sapiens. This last line could, according to Leakey, be traced elsewhere through such types as Vértesszöllös, Swanscombe, Steinheim and Omo (Leakey and Goodall, 1970; Leakey 1972). The new Omo remains (Leakey, Butzer and Day, 1969), in his opinion, were closely

similar to the Kanjera crania and confirmed the existence of Homo sapiens of modern type in the Middle Pleistocene. However he thought that some Upper Pleistocene hominids such as Neanderthal, Rhodesian and Solo man were not "over-specialised" as he formerly believed, but were perhaps the result of cross-breeding between Homo sapiens and Homo erectus (Leakey, 1972). Leakey's controversial claims about the independence of the ancestral Homo sapiens line from Homo erectus are still plausible in the light of new discoveries at East Rudolf by an expedition led by his son (R. Leakey, 1973).

(iii) Theories deriving both "classic" Neanderthal and modern man from a single "generalised" or "progressive" pre-Würm population

From his own work on the fossil remains of Saccopastore and Monte Circeo, Sergi developed a theory which lay between the extremes of Hrdlička's unilinear theory and Boule and Vallois' conception of human evolution. Sergi created the category "Prophaneranthropi" for the Swanscombe and Fontéchevade remains, and regarded this group as morphologically intermediate between the "Palaeanthropi" (equivalent to the Neanderthal group, broadly defined) and the "Phaneranthropi" (modern man) (Sergi 1953, 1958). However Sergi cautiously refused to state that these intermediate features actually inferred an evolutionary relationship, especially as the remains in question were incomplete and shared so many characteristics with the "Palaeanthropi" (Sergi, 1953). Furthermore the Riss-Würm "Palaeanthropi" (e.g. Ehringsdorf and Saccopastore) also showed characteristics resembling modern man rather than the latest Neanderthals. He did not state absolutely whether such a group could be linked to the evolution of modern Homo sapiens but he clearly excluded the later Würm Neanderthals from such a position since he regarded them as adapted to the glacial conditions of Europe, particularly in their specialised nasomaxillary structure. Their small degree of variation and "lack of balance between the individual organs" led to their eventual extinction (Sergi 1953, 1958).

In the light of the re-dating of several supposedly ancient specimens of modern man by the fluorine

method, Howell reviewed the whole question of the place of Neanderthal man in human evolution (Howell, 1951). He discussed the temporal and geographic range of the Neanderthal fossils and divided them into "early" and "classic" types, which differed morphologically from each other in a number of features. Howell described the characteristics of these two groups in some detail and compared them in a number of osteometric measurements, for which he relied heavily on other workers. His early Neanderthal group included Tabun and Skhūl, at that time dated to before the Würm glaciation, and he concluded that the early Neanderthal group gave rise to the "classic" Neanderthals in Europe, and modern man farther to the East.

In a detailed study of the Pleistocene glacial ecology, Howell examined the ways in which geochronology, climatic change and archaeology supported his division of the Neanderthals (Howell, 1952). He concluded that the "classic" Neanderthals were isolated remnants of a group formerly more widespread, and that they evolved their specialisations in response to the European glacial conditions.

As a result of the re-dating of the Mount Carmel remains, Howell subsequently modified his views (Howell, 1957). He warned against the loose application of the term "Neanderthal" to fossils of varying morphologies since this obscured rather than clarified the relationships of such groups. He stated that neither the old idea of two long-distinct lines of human evolution, nor the concept of a "Neanderthal phase" were any longer useful in discussing the evolution of modern man. He suggested that

the re-dating of the Mount Carmel remains to a time contemporary with the "classic" Neanderthals made the Skhūl population the most plausible ancestors for the Cro-Magnons, and that they evolved from a stock similar to the early Neanderthals of Europe.

Le Gros Clark (1966) followed Howell (1952) in suggesting that Homo neanderthalensis was a cold-adapted species which persisted until the end of the first phase of the Würm glaciation and then disappeared without contact with the succeeding Aurignacians. He postulated that "a primitive type of H. sapiens retaining strongly developed brow ridges came into existence by the Middle Pleistocene .....; that H. neanderthalensis arose as an aberrant (and, in some respects, a retrogressive) collateral line from a pre-Mousterian or early Mousterian variety of H. sapiens; and that the former species eventually became extinct" (Le Gros Clark 1966 p.76).

The model of phyletic evolution marked by "polytypy in a genetically open racial network" favoured by Breitinger (1957) is similar to that of Le Gros Clark, Howell and Sergi. However whilst Le Gros Clark (1966) classified the common ancestors of the "classic" Neanderthals and modern man as "early Homo sapiens", Breitinger stressed the Neanderthal affinities of such forms as Swanscombe and Steinheim (Breitinger, 1957, 1964).

(iv) Theories postulating direct evolution from Neanderthal to modern man

As the fossil evidence for human evolution became more extensive, certain anthropologists attempted to arrange the fossils in a single evolutionary series rather than view the process of human evolution as one of increasing variation and "splitting" of lines. One of the first of these was Schwalbe who suggested that there were three main stages of human evolution; Pithecanthropine Neanderthal and modern (see Brace, 1964).

One of the few authorities to maintain and develop this scheme, despite the weight of the scholarship of Boule and Keith opposing it, was Hrdlička. His views on human evolution were presented most succinctly in the Huxley Memorial Lecture for 1927 (Hrdlička, 1927) and expanded in a later publication (Hrdlička, 1930). In his opinion the Neanderthals were a broad and variable group representing a whole phase of human evolution; and on physical and cultural grounds were the most plausible ancestors of the Aurignacian populations. He endeavoured to show inconsistencies in the arguments of other authorities who favoured the theory of the complete extinction of Neanderthal man. These included the facts that no other mammalian fauna died out between the Mousterian and Aurignacian periods, and that the way of life of the human populations of these periods was similar, even down to the sites and caves occupied.

An inventory of the remains known in 1927 demonstrated on the one hand, the unsatisfactory dating of many important palaeolithic human fossils and on the

other, the variable and mosaic nature of the supposed Neanderthal characteristics. These were, in fact, to be found in varying degrees in Upper Palaeolithic fossils and even in modern populations. In his opinion a list of such characteristics linked Neanderthal and modern man, rather than separated them (Hrdlička, 1930 pp. 319-322). Despite this detailed listing of morphological features he still ultimately preferred a cultural definition for the term "Neanderthal" (ibid. p.328).

It is to be regretted that Hrdlička wrote so little on the Pekin remains, and nothing on discoveries such as Swanscombe and Steinheim. The placement of certain fossils in his evolutionary scheme was already unclear. For example in the case of Rhodesian man he was "at a loss as to just where it belongs taxonomically or chronologically. It is a comet of man's prehistory." (Hrdlička, 1930). In 1930 he could only comment "they give us Homo sapiens, without showing why, or how, and where he developed his superior make-up." In his view "progressive infantilism" and the increased selection pressures of the Ice Age were responsible for the direct evolutionary change from Neanderthal to modern man which he postulated (Hrdlička, 1930).

A more detailed and world-wide network of hominid evolution was proposed by Weidenreich, based primarily on his studies of the Pekin material (Weidenreich 1936, 1937, 1943 a). His scheme applied to the four continents of Europe, Asia, Africa and Australasia and there was no single cradle of mankind (Weidenreich, 1949). In various parts of the world, hominids of the stages Archanthropinae, Paleoanthropinae and Neoanthropinae would

be discovered representing continuous evolutionary series, although in different areas the stages would not necessarily coincide chronologically (Weidenreich 1940, 1943 b, 1947, 1949). Different rates of evolution would also produce "mosaic" characters in the fossils, combinations of "advanced" and "primitive" features found together in one individual, as he noted in "Sinanthropus" (Weidenreich 1936, 1937, 1943 a).

As far as the actual positions of fossils in the postulated lines were concerned, the most complete line which he could trace was "Pithecanthropus" - "Homo soloensis" - Cohuna man - modern Australian aborigine. However similar lines from Pekin man to the Mongoloids, Rhodesian man to the Negroids and Neanderthal man to the Caucasoids would, he predicted, be completely known with further discoveries (Weidenreich 1943 b, 1947).

With reference to Neanderthal man, he accepted that some of the earlier "Neanderthaloids" such as Ehringsdorf, Steinheim, Galilee and Skhūl (at that time dated to the last interglacial), and perhaps also Krapina and Swanscombe, were more "advanced" than the later Neanderthals. He could thus state that the European Neanderthals represented possible ancestors of Homo sapiens but that the actual evolutionary transformation occurred outside Europe through types like the early Neanderthal group (Weidenreich, 1943 b). It is never entirely clear what he believed to have happened to the "classic" Neanderthals, but in one of his last publications he stated "what we call Neanderthal man is a widely spread evolutionary phase which may well have perished in one circumscribed territory, but have flourished, expanded,

and been transmuted somewhere else, and so have given origin to Homo sapiens" (Weidenreich, 1949).

Weidenreich's ideas have been developed in greater detail by Coon (1963), utilising new data obtained since Weidenreich's death. Virtually every known human fossil is placed into one of the five geographic lines of Australoids, Mongoloids, Caucasoids, Congoids and Capoids. Coon stated that "Homo erectus then evolved into Homo sapiens not once but five times, as each subspecies, living in its own territory, passed a critical threshhold from a more brutal to a more sapient state." (Coon 1963 page 657). The boundary between these two species was fixed by Coon primarily on brain size, and secondarily on the general massiveness of the skull. Thus Rhodesian man and Solo man were regarded as Homo erectus, but Swanscombe and Steinheim, although much earlier in date, were Homo sapiens. Coon believed that the Congoid line for example "stood still for half a million years" but nevertheless could subsequently produce the modern Negroid race in a very short period of time (Coon 1963, page 658). These proposals have been criticised by several other authorities (among them Dobzhansky 1964; Le Gros Clark 1966; Howells 1967).

In Coon's view the Neanderthals of the Middle East and Europe were part of the Caucasoid lineage which can be traced back through Swanscombe and Steinheim to the Heidelberg mandible. This lineage was always variable enough to include small-browed specimens like Fontéchevade. The "classic" Neanderthals of the Würm glaciation were variants showing adaptations to the extreme cold of their

environment, but a "cline" of decreasingly "classic" features existed across Europe towards the Middle East. In this region the evolution of modern Caucasoids occurred through types like Shanidar and Skhūl IV and these forms gradually migrated West with Upper Palaeolithic industries, absorbing the more "classic" populations as they penetrated into Europe (Coon, 1963).

Soviet anthropologists have, in general, adopted the views of authorities such as Hrdlička that there was widespread evolution of Palaeoanthropes (Neanderthals) into modern man. Nevertheless the influence of Boule can be detected in descriptions of Neanderthal remains from the Soviet Union which are said to show various simian characteristics of the skeleton. The hands and feet of the Kiik-Koba skeleton are said to be primitive in a number of respects (Nesturkh, 1967) although alternative reconstructions produced from casts in England by Professor P.R. Davis are modern in form (Brothwell, personal communication, 1973). Soviet studies of fossils such as Swanscombe have similarly emphasised the primitive or "Neanderthaloid" affinities of these remains (Nesturkh, 1967; Roguinsky, 1972). Attitudes towards theories excluding the Neanderthals from the ancestry of modern man are generally harsh and politically motivated - for example Nesturkh (1967) says "an analysis of the Eoanthropus finds demonstrated the failure of an attempt by bourgeois scientists to prove that modern man is more ancient than the Neanderthaler, his predecessor."

The views of Hrdlička, Weidenreich and Weinert on the Neanderthal phase of human evolution have recently been strongly revived by Brace and others. In 1962 he

produced a short paper calling for a re-examination of the Neanderthal-Upper Palaeolithic relationship, particularly in the light of Bordes' new work on the Mousterian-Upper Palaeolithic transition (Bordes 1958; Brace 1962 b). In a much more detailed and polemical paper, Brace attempted to show that many anthropologists who would not accept a Neanderthal-modern evolutionary transition were adopting, consciously or unconsciously, an anti-evolutionary or even "catastrophist" position (Brace 1964). In a very full review of the literature he examined how "schools of thought" and accidents of discovery had served to remove the Neanderthals to a peripheral position in human evolution. The evidence of "early modern" fossils was dismissed on the grounds of incorrect description (Swanscombe, Steinheim) or uncertainty of morphology or date (Fontéchevade, Grimaldi, Krapina). Furthermore according to Brace new discoveries of Neanderthals in the Middle East, and the redating of the Mount Carmel remains had undermined not only the "pre-sapiens" theory of Boule, Vallois, Keith and Heberer but also the "modified catastrophism" represented by the "pre-neanderthal theory" of Sergi, Howell, Breitinger, Le Gros Clark and others.

Near the end of the article Brace finally dealt with the question of a definition of the term "Neanderthal" He favoured a cultural definition like that of Hrdlička (1930 p. 328) but modified it as follows: "Neanderthal man is the man of the Mousterian culture prior to the reduction in form and dimension of the Middle Pleistocene face." To Brace culture itself was the primary determinant of evolutionary changes during the Pleistocene. Using earlier work (Brace 1962a, 1963) he suggested that

increasing cultural adaptations could have led to a reduction in what he termed the "Middle Palaeolithic" dentition and its supporting facial architecture. By concentrating on the face and dentition, Brace virtually ignored all the other differences between Neanderthal and modern man, especially those of the post-cranial skeleton (Howell 1951, 1957; Stewart 1960, 1962).

Brace resurrected Schwalbe's evolutionary scheme with the addition of a fourth stage (Australopithecines) and has developed it in two books (Brace 1967; Brace, Nelson and Korn 1971). But the rigidity of this scheme meant that, for example, the robust Australopithecines had to be the ancestors of Homo erectus if they were chronologically later than the gracile forms (Brace 1967). The necessity to find a "Pithecanthropine" stage all over the Old World meant that fossils such as Swanscombe and Fontéchevade were classed in this group, whilst Rhodesian and Solo were "Neanderthal", and Amud "Modern" (Brace, Nelson and Korn 1971). Furthermore the term "Neanderthaloid" (applied to fossils such as Amud, Skhūl Predmost and Wadjak) is used by Brace in a very different way to the usage of anthropologists such as Weidenreich, Le Gros Clark and Howell (Brace 1967; Brace, Nelson and Korn 1971).

Closely following Brace's arguments, Brose and Wolpoff examined the archaeological and morphological evidence for an evolutionary change from Neanderthals to modern Homo sapiens (Brose and Wolpoff, 1971). Ignoring Howell's warning that loose definition of the term "Neanderthal" could only cloud evolutionary judgement (Howell, 1957), their category "Neanderthal", which is

defined chronologically (Brose and Wolpoff 1971, page 1156), includes the Omo, Qafza and Skhūl remains. It is hardly surprising that they concluded that such a group could have given rise to modern man, since several authorities had already classed these particular fossils as modern in form (Brothwell, 1961; Day, 1969, 1972, 1973; Howells, 1970a; L.S.B. Leakey, 1972; Vandermeersch, 1972; Vallois and Vandermeersch, 1972). Brose and Wolpoff subdivided the "Neanderthal" group into "classic" and "other" Neanderthals, and calculated coefficients of variation for a number of cranial measurements. These showed that the "classic" group were as variable as other control populations, and were not extremely uniform in their characteristics as claimed elsewhere (e.g. Morant, 1927; Howell, 1951; Sergi, 1958; Coon, 1963). The values of the coefficient of variation of the "classic" Neanderthals calculated by Brose and Wolpoff are comparable to those calculated by the present author, although they included Petralona in the "classic" group, probably incorrectly (Von Koenigswald 1967; Jelínek 1969; Suzuki 1970; Hemmer 1972a, 1972b; Kurtén 1972; Stringer 1972, and in press).

Thus the hypothesis that Brose and Wolpoff put forward is that cultural change reduced selective pressures on a large anterior dentition and a cold-adapted face in the "classic" Neanderthals. Hence facial reduction occurre and alterations in cranial mass distribution produced a more modern morphology. This idea is similar to that of Brace already discussed, and is supported by the work of Bilsborough (1971, 1972) discussed elsewhere, and Suzuki. From his study of the Amud skull (Suzuki, 1970) he

concluded that it was morphologically intermediate between the Shanidar-Tabūn-Galilee group and that of Skhūl-Qafza. However his use of Penrose's shape distance statistic showed a marked gap between the Amud cranium and the Skhūl crania, which were always much closer to modern man (Suzuki, 1970). Nevertheless he too proposed that some behavioural or technological change occurred amongst the Middle-East Neanderthals which led to dental and facial reduction, and hence the evolution of the modern face and skull form (ibid.).

These views on the evolution of Neanderthal man into modern Homo sapiens concentrate on the causes of facial reduction, ignoring the various other changes which would have to occur in the skull and post-cranial skeleton. The first descriptions of the Qafza VI cranium (Vallois and Vandermeersch, 1972) do not support them. Although the vault of this skull needed extensive restoration, the face was quite complete and apparently distinctively modern in form. Therefore this facial form had evolved before the Upper Palaeolithic industries, since the Qafza skull was associated with a Mousterian industry. Furthermore the dentition and palate are both large in this specimen, resembling the dimensions of Neanderthals, with large anterior teeth. Hence evolution of the modern facial form probably occurred independently of anterior dental reduction, without an intermediate "Neanderthal" stage. A similar combination of large palate and dentition with a more modern facial form also occurs in the Djebel Irhoud I skull (Ennouchi, 1962; Suzuki, 1970).

(v) The "Spectrum Hypothesis"

Weiner (1957) suggested that theories of human evolution should be erected using only the best known and best dated fossil material. Isolated specimens would remain of uncertain status if they did not fit a theory which was otherwise consistent with the majority of fossil evidence. The "New Systematics" (Dobzhansky 1944, 1964; Mayr 1950, 1964) demanded a taxonomy of continuity, both temporal and morphological, between the various fossil populations (Weiner 1958). "From the Steinheim-Swanscombe stage onwards one can therefore discern temporally, as well as spatially, a succession or spectrum of the various groupings that constitute the genus Homo" (Weiner 1958; note p. 531). This "spectrum hypothesis" has been used by other workers in studies of particular fossils (for example Brothwell 1961; Weiner and Campbell 1964; Howells 1970a) and has led to new classifications of hominid fossils. Weiner and Campbell (1964 p. 207) stated "the degree of interrelatedness implied in the "spectrum hypothesis"..... .... is such that it is not possible to maintain in a taxonomic sense strict specific status for each of the various forms of Homo; Solo, Rhodesian, Neandertal, modern sapiens." Hence Campbell (1964) reclassified these various forms of late Pleistocene hominids as subspecies of Homo sapiens.

CHAPTER TWO: MATERIALS AND METHODS

Chapter 2

Materials and Methods

(i) Fossil material studied (see Figures 51-54)

Previous comparative studies of fossil hominids, both univariate and multivariate, have generally been unsatisfactory in that they compared only a small number of specimens, often predominantly casts, in a small number of measurements. Furthermore some anthropologists have been content merely to collate other scholars' osteometric work, despite differences in the definitions and techniques found between various authors.

The aim of the present author was to examine and measure as large a sample of later Pleistocene hominid crania as possible for himself, using original material whenever it was made available. The measurements employed had been selected and defined by Howells on the basis of his long experience in craniometry and had already been proven in studies of recent populations to provide data which could be fruitfully studied by multivariate analysis (Howells, 1966, 1969a, 1969b, 1970a, 1970b, 1973). In the majority of cases where requests were made the author was given access to original fossil material, but in the cases where such permission was denied, or the remains were unavailable, casts were studied instead.

The following list of fossil material measured shows which specimens were studied in original or cast form, and also includes the sex assigned to the specimens by the present author. The numbers identifying the specimens are in accordance with the recent Catalogue of Fossil Hominids (Oakley and Campbell 1967; Oakley, Campbell and Molleson

1971) wherever possible, and the abbreviations accompanying the fossils are those used by the present author in this thesis. Where individual fossils are grouped into larger populations this is indicated after the fossils by the abbreviation of the appropriate population name. The recent comparative material used in the study (kindly provided by Professor Howells) is also included in the list. (* originals studied, M = male, F = female).

Abbreviation		Fossils studied	Population
A.C.	*	Arene Candide 1,4,6(M)	(U.P.)
Af	*	Afalou 9(M), 10(M), 29(F), 32(M)	(Me)
Am		Amud 1(M)	(M.E.N.)
Br		Brno 1(M), 2(M), 3(F)	(U.P.)
C.C.		Combe Capelle(M)	(U.P.)
Ch	*	Chancelade(M)	(U.P.)
Co		Cohuna(M)	
Cr	*	Cro-Magnon 1(M), 2(F), 3(M)	(U.P.)
D.I.	*	Djebel Irhoud 1(M)	
D.V.	*	Dolni Vestonice 1(M), 2(M), 3(F)	(U.P.)
Eh		Ehringsdorf 9(F?) (Behm-Blancke reconstruction)	
En	*	Engis 1 (M?)	(U.P.)
Es		Recent Eskimo (Howells' series) (54M, 54F)	(Es)

Abbreviation		Fossils studied	Population
F.J.	*	Cheddar-Flint Jacks	(U.P.)
		Cave 1(F?)	
Fe		La Ferrassie 1(M)	(Nea)
Fo	*	Fontéchevade 5(M?)	
G.C.		Cheddar-Gough's Cave 1(M)	(U.P.)
Ga		Galilee(F)	(M.E.N.)
Gi	*	Gibraltar 1(F)	(Nea)
Gra	*	Gramat 1(M)	(Me)
Gri		Grimaldi 6(M)	(U.P.)
Hoh	*	Hohlenstein 1(M),2(F)	(Me)
Hot		Hotu 1(M)	
I.E.	*	Iwo Eleru(M)	
Ja		Pithecanthropus 2 (F?)	
Kan	*	Kanjera 1(M?)	
Kau	*	Kaufertsberg 1(M)	(Me)
Ko		Kostienki 2(M?)	(U.P.)
Kr	*	Krapina C(F?) E(F?)	
L.B.	*	Laugerie-Basse 2(F), 4(M)	(U.P.)
L.Ch	*	La Chapelle(M)	(Nea)
L.R.	*	Le Roc 2(F)	(U.P.)
Lan		Langwith 1(M)	
Lau	*	Lautsch(Mladeč) 1,5,6(M)	(U.P.)
M.C.	*	Monte Circeo 1(M)	(Nea)

Abbreviation		Fossils studied	Population
M.E.N.		Middle-east Neanderthals	(M.E.N.)
Ma	*	Maritza 2(M)	(U.P.)
Me		Mesolithic	(Me)
Mo		Le Moustier(M)	(Nea)
N.V.	*	Neander Valley(M?)	(Nea)
Nea		Classic European Neanderthals	(Nea)
Neu	*	Neussing 2(M)	(U.P.)
No		Medieval Norse (Howells' series) (55M, 55F)	(No)
Ob	*	Oberkassel 1(M), 2(F)	(U.P.)
Of	*	Ofnet 2(F), 11(M), 25(M)	(Me)
Ol	*	Olmo(M)	(U.P.)
Om		Omo 1, 2 (M?)	
Or	*	Ortucchio 1(F)	(U.P.)
Pek		Pekin Locus E(M?), L 1(M?), 2(F?), 3(M?)	(Pek)
Pet	*	Petralona(M)	
Po		Podkumok(M?)	
Pr		Predmost 3(M), 4(F)	(U.P.)
Qu	*	La Quina 5(F?)	(Nea)
Rh	*	Rhodesian 1(M)(Broken Hill)	
S.T.	*	S. Teodoro 3,4(M)	(U.P.)
Sac	*	Saccopastore 1(F?), 2(M)	

Abbreviation	Fossils studied	Population
Sala	Sala (F?)	(Nea)
Sald	Saldanha(F?)	
Si	* Singa(M?)	
Sk	Skhūl 5(M), 9*(F?)	(Sk)
So	* Solo 1(F?), 4(F?), 5(M), 6(F), 9(F?), 10(F?),11(M?)	(So)
Sp	* Spy 1, 2 (M?)	(Nea)
St	Steinheim (F)	
St.R.	Steinheim reconstruction (F) (Breitinger's reconstruction)	
Stt	* Stetten 2(M)	(U.P.)
Sw	* Swanscombe(F?)	
Tab	* Tabūn 1(F)	(M.E.N.)
Taf	* Taforalt 11(M), 17(F)	(Me)
Tas	Tasmanian aborigines (Howells' series) (44M, 42F)	(Tas)
Te	* Teviec 1(F), 11(M)	(Me)
Ti	* Tilbury 1(M)	
U.P.	Upper Palaeolithic	(U.P.)
Ve	Vértesszöllös 2(M?)	
Zu	Recent Zulu (Howells' series) (55M, 47F)	(Zu)

Most of the fossils listed above have been catalogued in detail in the Catalogue des Hommes Fossiles (Vallois and Movius 1952) and the Catalogue of Fossil Hominids (Oakley

and Campbell, 1967; Oakley, Campbell and Molleson, 1971). To avoid extensive repetition the relevant literature will not be reviewed again. However certain fossils which have been reassessed, or new fossils discovered recently will be discussed below if they are not adequately covered in the above mentioned Catalogues.

The population groupings used in the list are generally justifiable on chronological or geographic grounds. The Upper Palaeolithic and Mesolithic populations are defined according to their chronology (Würm or post-Würm) and their industrial association (Upper Palaeolithic and Epi-Palaeolithic or Mesolithic) using data provided by the Catalogue of Fossil Hominids (Oakley and Campbell, 1967; Oakley, Campbell and Molleson, 1971). The "classic Neanderthals" are those generally dated to the early Würm of Europe, and the "Middle-East Neanderthals" are those remains contemporary with the "classic Neanderthals" which are associated with each other on morphological, chronological and archaeological grounds from the Middle East (Howell, 1957; Stewart, 1960, 1962; Higgs, 1961; Brothwell, 1961; Suzuki and Takai, 1970). The Skhūl remains are treated in this study as a separate population (Brothwell, 1961; Howells, 1970a). The Omo crania are regarded here as individual crania, rather than members of one population (see discussion below).

Amud

The Amud 1 cranium was discovered in a cave at Wadi Amud in 1961 (Suzuki and Takai, 1970). The deposits in which it was found were thought to belong to a time equivalent to the Göttweig interstadial of Europe (Takai and Chinzei, 1970), and these same deposits yielded an

industry said to be transitional between those of the Middle and Upper Palaeolithic (Watanabe, 1970). In its general morphology the Amud 1 skull was closest to the Shanidar material, particularly Shanidar 1 (Stewart, 1959), but displayed more advanced features such as a reduced supraorbital torus, facial reduction and greater development of the chin (Suzuki, 1970). Post-cranially the Amud material generally resembled the Neanderthal populations, and shared the characteristics of a flattened and plate-like pubic bone with the Middle-East Neanderthals from Tabūn and Shanidar, in contrast to the features of the Skhūl pelves (McCown and Keith, 1939; Stewart, 1960; Endo and Kimura, 1970).

Penrose's shape distance test was applied to fourteen and fifteen cranial measurements of the Amud 1 skull with Mesolithic, Upper Palaeolithic and Middle Palaeolithic skulls included in the test for comparison. The results confirmed that Amud 1 was morphologically similar to the Neanderthals especially the Shanidar 1 skull, and unlike the Mesolithic and Upper Palaeolithic populations. The Skhūl crania occupied an intermediate position, but were not very closely related to Amud 1 (Suzuki, 1970). Nevertheless Suzuki concluded that Amud was morphologically intermediate between the Shanidar-Tabūn-Galilee group and that of Skhūl-Qafza, and he suggested that dental and facial reduction led to the evolution of the latter group from the former through types like Amud. A similar view has been expressed by other authors (Brose and Wolpoff, 1971; Brace, Nelson and Korn, 1971).

Cohuna

The Cohuna skull was discovered in late Pleistocen

or early Holocene deposits in Victoria, Australia in 1925 (Macintosh, 1952). Keith regarded it as showing primitive features which related it to the Talgai skull (Keith, 1931) but other workers suggested it was within the range of variation of modern aboriginal crania (Mahony, 1943). Weidenreich (1943b) considered it part of the evolutionary lineage from "Pithecanthropus" and Solo man leading to the modern aborigines, and similarly Coon (1963) suggested it was Australoid with features of the frontal bone, face and palate recalling its descent from Homo erectus.

The skull is particularly massive in the facial region and has a remarkably long and flattened frontal bone. The Cohuna cranium is in fact similar in these respects to the recently excavated Kow Swamp material which is said to show Homo erectus features (Thorne and Macumber, 1972). However this view has been disputed (Anonymous Nature editorial, 1972) and Brothwell believes the "primitive" characteristics of the frontal bone could have been caused by cranial deformation, as may be the case in the Choukoutien Upper Cave "Melanesian" skull (Brothwell, personal communication, 1973). Only further studies of the original material or new discoveries of remains of early Australian populations can resolve this problem.

Djebel Irhoud (or Jebel Ighoud)

The Djebel Irhoud 1 cranium was discovered in Morocco in 1961 (Ennouchi, 1962), and an additional calvaria was discovered by Coon in 1963 (Ennouchi, 1968). Only the first and more complete cranium was measured in this study since the reconstruction of the second specimen is

unsatisfactory (Vallois and Heim, personal communication, 1971). Ennouchi (1962)stated that the Djebel Irhoud I skull was a variant of Neanderthal man and that such differences as existed could be explained by the greater antiquity of the Djebel Irhoud specimen. In fact the date of the Irhoud remains is probably contemporary with the European Neanderthalers of the early or Middle Würm since the associated industry is described as Levalloiso-Mousterian (Ennouchi, 1963) or Mousterian (Balout, 1965), and the faunal remains suggest a Soltanian date (Ennouchi, 1963) or perhaps a Pre-Soltanian date (Biberson, 1964).

The generalised or even primitive characteristics of the first Irhoud skull suggested to Suzuki that it was most similar to the Petralona skull rather than the Middle East Neanderthals (Suzuki, 1970). Ferembach (1972) proposed that its modern facial characteristics made it a plausible ancestor for the Ibero-Maurusian late Palaeolithic and Mesolithic populations of North Africa, through a stage unrepresented in the fossil record, but marked culturally by the Aterian industry. Similarly the Djebel Irhoud skull is said to "morphologically foreshadow" the Afalou material (Brace, Nelson and Korn, 1971).

Iwo Eleru

The Iwo Eleru skeleton was discovered in a large rock shelter in Nigeria in 1965. The dating of the find is late Pleistocene or early Holocene with an associated radiocarbon date of 9,250 B.C. and late Stone Age tools. The calvaria needed extensive restoration and the face could not be reconstructed. The vault of the skull has been described as long and low, with a moderately receding fronta

bone, but features of the frontal bone, occipital and nasal root led Brothwell and Shaw (1971) to suggest that it could nevertheless represent a proto-West African Negro.

Omo

Of the three fragmentary human crania recovered in Ethiopia by the Kenya group of the 1967 International Omo Expedition, two were complete enough to be restored with some confidence. These crania, Omo 1 and 2, are said to be contemporaneous, and may belong to the Upper Middle Pleistocene (Leakey, Butzer and Day, 1969; Day, 1972, 1973). However the morphology of these skulls is dissimilar, one skull (Omo 1) being comparable to the Swanscombe and Skhūl material, the other (Omo 2) recalling the Solo, Rhodesian, Vértesszöllös and Kanjera remains, or even Homo erectus (Day, 1969; Day, 1972, 1973). Leakey commented that "the new skull-caps conform in all major details with the Kanjera material" (L.S.B. Leakey, 1972). Brose and Wolpoff (1971) regarded Omo 1 as a transitional specimen like Amud, and Omo 2 as a basically similar form, differing in a number of details. In their view the resemblances between Omo 2 and the Solo material, especially Solo 5, are not surprising as East Africa is "in a sense geographically between Java and the Middle-East"!

All the authors quoted above seemed to regard the Omo material as representing a single evolving population of Homo sapiens. However the crania were discovered about 2.5 km apart and Omo 2 was in fact a surface find (Butzer, 1969). Accordingly the present author has decided to treat the crania separately in this study in the light of their apparent morphological differences and pending a fuller report with more detailed dating evidence.

Petralona

The Petralona cranium was discovered in a stalagmitic deposit in Greece during cave exploration in 1959 (Oakley, Campbell and Molleson, 1971). Although the skull was in an unstratified deposit without directly associated faunal or cultural material it has generally been dated to the end of the Riss-Würm interglacial, or the beginning of the Würm, perhaps 70,000 years B.C. (Poulianos, 1967, 1971). The skull has not been fully described but some authorities have classed it as a classic Neanderthal form, whilst others have stressed its resemblance to the early Neanderthals (see Poulianos, 1967) or Rhodesian man (Bostanci, 1964). It has even been said to show some features of modern Homo sapiens (Poulianos, 1972).

In the light of the circumstances of its preservation Bostanci (1964) suggested that it had been deposited by a flow of water, and hence could have been derived from more ancient levels. Jelínek (1969) suggested that morphologically the Petralona cranium was one of the most primitive examples of Homo sapiens neanderthalensis, with some characteristics reminiscent of Homo erectus. Von Koenigswald (1967) has similarly viewed it as intermediate between Homo erectus and Neanderthal man, and compared the morphology of the rear of the skull with the Vértesszöllös occipital, but Thoma (1969) disagreed with his conclusions and maintained that they were separate types.

The dating of the Petralona skull is unsatisfactory, and Kurtén (1972) suggested that it should be placed in the Günz-Mindel (Cromerian) interglacial and was hence contemporary with the Heidelberg mandible. Greek archaeologists had already excavated deposits dating back

to the Mindel glaciation from the Petralona cave (Poulianos, 1971) but Kurtén (1972) and Hemmer (1972) quoted the identification by Schütt of bones representing a hyaena similar to Crocuta crocuta praespelaea from the cave. This hyaena became extinct in Europe during the Günz-Mindel interglacial, and if the skull was derived from such a deposit it would represent the oldest cranial evidence of man in Europe. Kurtén believed the Petralona skull and the Heidelberg mandible represented the point of origin of Homo sapiens from Homo erectus, and that this comparatively advanced European line gave rise to the Vértesszöllös-Swanscombe-Steinheim group (Kurtén, 1972). Similarly Hemmer (1972) suggested it could represent an ancestor of the Neanderthals, but was in fact a member of the lower Middle Pleistocene erectus group.

At present the chronological and morphological position of the Petralona remains are uncertain. It is possible that further discoveries will be made in the Petralona cave, or that new discoveries from France at sites such as Arago (de Lumley and de Lumley, 1971; Poirier, 1973) will throw light on the relationships of the Petralona fossil. For the moment one can only recall the comments of Hrdlička about Rhodesian man - "the student.... is wholly at a loss as to just where it belongs taxonomically or chronologically. It is a comet of man's prehistory." (Hrdlička, 1930).

(ii) Measurements and techniques employed (see page 39)

Anthropologists have been measuring human skulls for over a century without coming to any agreement amongst themselves on which measurements are the most useful in expressing size and shape differences between crania. Various attempts have been made to standardise osteometric procedures but these have invariably been unsuccessful, and this fact demonstrates the dangers of comparative studies using measurements taken by several workers where such measurements are defined and taken in different ways. Studies which attempt to describe skull form mainly by visual inspection are even more subjective as can be seen by the very varied assessments made by prominent anthropologists of material such as Swanscombe and Steinheim.

Howells (1969a) stated about choice of cranial measurements "we can doubtless be more imaginative, paying less attention to Martin's list and more attention to subtleties of shape and anatomical meaning". He has selected and carefully defined seventy cranial measurements and angles on the basis of his long experience in craniometry, and these same measurements were employed by the present author in this study of Pleistocene human crania. Originally defined in a pre-publication typescript draft, descriptions of the measurements and the results of the multivariate analyses employing them are now available in a detailed monograph (Howells, 1973). The instruments employed were a series of generally standard calipers, some of which were slightly modified to enable angles and radius measurements to be taken. These are also described by Howells (ibid.) and were employed by the present author in

this study.

Rather than follow Howells' conclusions gained from studying modern crania about which measurements were most useful, the present author took all the measurements wherever possible and then employed those which were present in the largest samples of fossil crania. The analyses were performed on separate areas of the skull to allow the optimum use of less complete material and these areas were determined simply by which parts of the crania were most commonly preserved, rather than by functional criteria (cf. Bilsborough, 1971). A total of 43 measurements and 5 angles were eventually employed in a series of 14 analyses, but computational factors necessitated the use of a maximum of 25 variables at any one time. The bregma-asterion chord was also taken on the parietal bones studied, since it had proved useful in the present author's preliminary studies. Additionally a further angle, which the author has named the bregma angle (BRA) was also computed, and this angle is merely the third angle of the triangle containing the nasion angle (NBA) and the basion angle (BBA) defined by Howells (1973) (some of the angles employed are represented diagrammatically in figure 3). The only other difference from the list of measurements used by Howells is that his zygomaxillare angle is here abbreviated as ZMA rather than SSA.

Short names for angles and variables used in

alphabetical order

ASB = biasterionic breadth
AUB = biauricular breadth
AVR = M1 alveolus radius
BAA = basion angle, NA-PR
BAC = bregma-asterion chord
BRA = bregma angle NA-BA
EKB = biorbital breadth
EKR = ectoconchion radius
FMB = bifrontal chord
FMR = frontomalare radius
FRC = nasion-bregma chord
FRF = nasion-subtense fraction
FRS = nasion-bregma subtense
GLS = glabella projection
GOL = glabello-occipital length
JUB = bijugal breadth
MAB = palate breadth
MDB = mastoid width
MDH = mastoid length
NAA = nasion angle, BA-PR
NAR = nasion radius
NAS = nasio-frontal subtense
NBA = nasion angle, BA-BR
NFA = nasio-frontal angle
NLB = nasal breadth
NLH = nasal height
NOL = nasio-occipital length
NPH = nasion-prosthion length
OBB = orbit breadth left
OBH = orbit height left
OCC = lambda-opisthion chord
OCF = lambda-subtense fraction
OCS = lambda-opisthion subtense
PAC = bregma-lambda chord
PAF = bregma-subtense fraction
PAS = bregma-lambda subtense
PRA = prosthion angle, NA-BA
PRR = prosthion radius
SOS = supraorbital projection
SSR = subspinale radius
STB = bistephanic breadth
VRR = vertex radius
WMH = cheek height
XCB = maximum cranial breadth
XFB = maximum frontal breadth
ZMA = zygomaxillare angle
ZMB = bimaxillary chord
ZMR = zygomaxillare radius
ZOR = zygoorbitale radius
ZYB = bizygomatic breadth

(iii) General review of previous applications of multivariate analysis to the study of fossil human crania

Weiner and Campbell (1964) were among the first to apply multivariate techniques to Pleistocene fossil material in their study of the Swanscombe skull. Calculating the Mahanolobis D^2 statistic for up to seventeen measurements of the parietal and occipital bones, separately and articulated, they examined the morphological distance of the Swanscombe remains from other fossil crania, and from a large sample of recent material. Penrose's size and shape statistic was also computed for the various crania, but since no adjustment was made here for the correlations between characters, Weiner and Campbell mainly drew their conclusions from the results of the D^2 distances. By examination of the morphological distances obtained they assigned Swanscombe broadly to the "Neanderthaloid" group, and noted that Swanscombe deviated from modern crania to a greater extent than Skhūl V.

Howells (1966) and Crichton (1966) performed parallel studies of early Japanese (Jomon) crania and Egyptian crania, employing discriminant function analyses to assess the likely relationships of the studied populations to other groups. In reviewing these papers Marshall (1969) questioned whether multivariate techniques actually had any advantages over more traditional methods of study. He concluded that no extra insight was contributed by these techniques, but they merely reaffirmed the value of observation and inspection.

Howells (1969c) reaffirmed his confidence in

multivariate techniques when he answered Marshall's criticisms. These techniques "reduce background "noise" in the form of individual phenotypic plasticity and genetic variation, and ..... identify the important parameters or factors chiefly responsible for the variation within and between populations." In a general article on multivariate techniques (Howells, 1969b) he further stated that univariate statistics did not provide a real vector or profile representing either individuals or populations. Using these required a mental summing-up of the relative significance of various measurement differences with closeness of mean measurement values between populations inferring a close relationship. However small differences which lay in opposite directions provided important information about shape differences in crania which were lost by univariate statistical analysis.

In contrast to the univariate approach, multivariate statistics provide that "the individual is not decomposed, but remains a vector of all his measurements taken together, with everything they convey as to size and shape via both absolute size and by covariation. Such a vector of measurements treats an individual as a point in space. This multivariate space, which has as many dimensions as there are measurements, is created by the population as a whole, or by several populations, all the individuals being located as points in the same space. Multivariate analyses consist in creating secondary or transformed variables on which to read the individuals and the populations. That is to say, they take the form of reference axes in space giving new sets of coordinates to locate the populations and the individuals" (Howells,1969b).

Howells' multiple discriminant function analyses applied to seventeen recent cranial populations and some extra problematical specimens have been described in several reports (Howells, 1970a, 1970b, 1973). The measurements and angles used were defined by Howells and were subsequently used by the present author for this study. The results of these analyses generally grouped the recent populations geographically e.g. Melanesians were closely related to Australians and Bushmen grouped with the African populations. Howells discovered that the primary differences in recent crania were in the breadth of base and vault together with facial height, in prominence of the glabella and subnasal region, and lastly in the flatness of the interorbital surface and forward prominence of the malar and orbital region. Such succinct statements of population differences in cranial measurements show the advantages of multivariate techniques over more traditional methods of study.

Using these same techniques Howells concluded that the Fish Hoek cranium was allied to the Bushmen, and the Keilor skull to the Tasmanians (Howells, 1969b). A study of the Skhūl V cranium and some Neanderthal material using similar methods led Howells to assign Skhūl V to the modern populations rather than to the Neanderthals (Howells, 1970a). However his methods necessitated the use of complete crania only, and in fact casts of reconstructed crania were used in place of the original fossil material which was less complete. Certain of Howells' conclusions regarding the Neanderthal crania must therefore be viewed with caution since the discriminant functions often depended upon measurements

of the nasal and dacryal regions where there were extensive areas of reconstruction in these specimens.

Recently Howells (unpublished) has circulated more measurements taken on a wider range of fossil crania. These will no doubt be studied further, but he did undertake univariate and multivariate comparisons (factor analysis) between the various crania. The measurements and angles were either obtained directly from original material or casts, or were taken from scaled photographs. Howells concluded that the Neanderthals showed various specialisations in the dentition and in the zygomatic and temporomandibular areas. Furthermore he considered it morphologically incorrect to class fossils such as Petralona, Solo, Steinheim, Broken Hill and Djebel Irhoud as Neanderthals since to varying degrees they differed from the "classic" Neanderthals.

An ambitious attempt to study rates of evolutionary change in the hominid cranium and dentition was made by Bilsborough (1971). Multivariate statistical analyses were employed to measure morphological distances between various fossil and recent hominoid populations, and rates of evolution between these populations were also calculated. The cranium was treated as consisting of eight functional complexes, and measurements taken on each complex were subjected to Mahanolobis's D^2 analyses and canonical variate analyses. The loadings generated by the canonical variate analyses were also used to compute the relative contributions of the characters to the results.

As Bilsborough stated "the prime aim is not one of discrimination. Therefore statistically significant

results.....are not crucial, and lack of significance does not necessarily render the results nugatory. In fact.....the discrimination between Pleistocene Hominidae was not significant owing to the fragmentary nature of the material" (Bilsborough, 1971 pp 260-261). The results most relevant to the present study were those concerned with Middle and Upper Pleistocene hominids. Studies of evolutionary rates of change derived from the statistic D and generally accepted dating evidence showed that the group "early H.sapiens" (Swanscombe, Steinheim) could reasonably have evolved from the "late H.erectus" (Pekin) group. Furthermore Bilsborough's results suggested to him that the Upper Palaeolithic populations were most plausibly derived from the classic Neanderthals, rather than the Mount Carmel populations (Bilsborough, 1971 p.4, pp. 805-807, 1972). These are rather surprising conclusions, but they are probably partly due to the fact that no original specimens were measured in the study, and that the "Middle East Neanderthal" population consisted of Tabūn I (extensively recontructed), Tabūn II (a mandible), Skhūl IV (not used in the present study due to the poor condition of available casts) and Skhūl V. The evidence that such fossils could represent a meaningful population is, on chronological and morphological grounds, very doubtful (Higgs, 1961; Brothwell, 1961; Howells, 1970a).

Nevertheless, Bilsborough's approach to the problem was a refreshing attempt to look at evolutionary change from a functional viewpoint. The underlying ideas were sound although the functional units chosen, the data taken from measurements of casts and the composition of groups used make the results equivocal. Additionally, the

assumption that the Pekin material was ancestral to later European material is doubtful, and choice of an alternative ancestral model such as Petralona (see Stringer, in press) would produce very different results. It is difficult to agree with his conclusion that "the pattern of hominid cranial evolution during the Middle and Upper Pleistocene is relatively well documented, and additional finds are unlikely to require substantial changes to the results presented here" (Bilsborough, 1971 page 820). Already new discoveries from sites such as Arago and Omo have raised doubts about the wisdom of such confidence.

(iv) Statistical Methods

Pearson (1926) made one of the first attempts at multivariate statistical analysis when he introduced the Coefficient of Racial Likeness (C.R.L.). In its original "crude" form this was a type of significance test whose magnitude would indicate whether samples were drawn from the same population. However the C.R.L. also came to be used as a coefficient of population distance and for this, because mutual intercorrelations were ignored in its computation and it was liable to vary according to the size of samples used, it was unsatisfactory. In 1928 Pearson modified the original C.R.L. to its "reduced" form so that sample size did not affect the value unduly, but the neglect of correlations between the characters used still caused exaggeration of racial affinity or divergence.

These deficiencies of the C.R.L. led to the introduction by Mahanolobis of the Generalised Distance statistic (Mahanolobis, 1936; Rao, 1952). This was both a test of significance and a measure of group divergence in which the mutual intercorrelations of the characters were considered, and in fact it was later shown to give identical results to the C.R.L. when the latter statistic was calculated using standardised and transformed (i.e. decorrelated) characters (Talbot and Mulhall, 1962). Since intercorrelations between the characters are taken into account, all of them are initially given equal weighting and redundant information is not included.

The following brief description of the computation of the D^2 statistic is taken from Kendall (1968). If two multivariate normal populations have the same dispersion matrix ($\propto ij$) with an inverse ($\&ij$) and means $\mu i1$, $\mu i2$

(i = 1, 2 ..... p) the distance between the means of variates may be defined as $\delta i = \mu_{i1} - \mu i2$ and the generalised distance for the population may be written

$$\Delta^2 = \sum_{i,j} \propto^{i,j} \delta_i \delta_j$$

and the corresponding formula for sample values:-

$$D^2 = \sum_{i,j} a^{ij} \quad di \quad dj$$

where $di = \bar{x}_{il} - \bar{x}_{i2}$

If the variates are independent the original formula reduces to $\Delta^2 = \sum \frac{\delta i^2}{\text{var } x i}$ and if the variates are scaled to provide unit variances then this becomes the square of the "distance" between the parent means in the customary sense. In most analyses the within-group dispersion matrix based upon sample values underestimates the population variability and hence the distances between populations will be overestimated leading to a biased D^2 value. However Rao (1952) has provided a correction factor which is subtracted from the computed D^2 value to provide an estimate of the unbiased Δ^2 value. Rao's correction is as follows:-

$$\Delta^2 = D^2 - \frac{n_1 + n2}{n1\ n2} \quad p$$

where p = number of variates

n_1 = sample size of first group

n_2 = sample size of second group

It will be seen that the correction factor will be extremely small where sample sizes are large, but where, say, single individuals are compared in a large number of measurements, the correction factor will be very large

(the correction will equal 50 when p = 25).

The D^2 statistic, as already mentioned, can also be used as a test of significance. Its value is multiplied by the factor n1 n2 / (n1 + n2) and then compared with the χ^2 value at a suitable level with p degrees of freedom. Examples of this test are given in the results of the present study.

Whilst Mahanolobis and others were developing the Generalised Distance statistic, another approach to the problems of quantifying population differences was made by Fisher, who from 1936 published works on "discriminant functions" in addition to providing a generalisation of the D^2 statistic for several populations. Oxnard (1972b) has produced a simple account of the method of canonical analysis which generates linear discriminant functions of weighted variables which maximise between-group variance whilst minimising within-group variance. More detailed accounts can be found in Seal (1964) or Bartlett (1965).

If p measurements are taken on q crania, q points can be visualised as representing the crania in a p-dimensional space. The original measurements can be replaced by $k < p$ linear functions, and the values can be represented in a space of k dimensions. These linear functions are selected to separate the groups in the analysis as widely as possible relative to their own dispersions. The linear functions are the solution of the equation:

$$(B - \lambda W)\, c = 0$$

where B and W are the variance-covariance matrices (dispersion matrices) between and within the populations. The latent roots or eigen values, λ , are proportional

to the between population variances of the corresponding linear functions. The solutions (c) to the equation are the canonical variates which are orthogonal i.e. uncorrelated with each other and each successive function removes as much as possible of the between-group variance not eliminated by its predecessors. The values of λ (the latent roots or eigen values) provide a measure of the discriminatory power of the associated canonical variate and can be used as significance tests for the canonical variates as described by Seal (1964). It should be noted here that the first few canonical variates generally account for most of the original variance, but whilst later canonical variates may not be significant when tested, they may still contain important information (Oxnard, 1972a).

The canonical variates themselves consist of summed products obtained by multiplying the elements of the vector c (the "loadings" or "weights") by the mean values of each character for each group. These loadings are scaled in the present analysis so that their grand means over all the groups are zero, and their within-group variance is equal to unity. Thus the groups can be directly plotted against each other using two or more canonical axes and equiprobability circles or spheres can be drawn around the group centroids to contain a calculated proportion of the group variability on those axes. The loadings can also provide information about the relative contributions of characters to the canonical variates scores, but in the present study the relative contributions of characters were computed directly from the D^2 analysis instead, since this contained <u>all</u> the information on group differences in singl

expressions. These contributions, called the coefficients of separate determination (Hope, 1968) were computed using a programme devised by Dr. M. Kidd. If the coefficients were negative this did not indicate that the variables concerned were adversely affecting the analyses, but that the variables were probably highly correlated with other variables with a greater positive weighting. Study of these variables gave valuable insights into patterns of variation between the crania in the analyses.

The generalised distances were subjected to a significance test at the 5% and 1% levels as described earlier, and significant values were then corrected for sample size differences using Rao's correction (Rao, 1952) to give an unbiased estimate of D^2. In order to further interpret the generalised distances matrices and to represent them in a simpler way, they were subjected to cluster analyses from which dendrograms were constructed. The principle employed was to place groups in sets with a minimum mean square distance between the constituent members at every level of the classification. In practice small sets were constructed first of the groups with non-significant or low mean square distances and these groups were agglomerated into larger groups ensuring that the fusion chosen gave the lowest possible increase in the total mean square distance within the group concerned. This method of clustering gave the smallest possible mean deviation from the group centroid and hence produced the most compact groupings.

However the method did tend to produce sets which were relatively equal in size but less equal in compactness at the same level. This was because the large

sets tended to force single groups or small sets together rather than fusing with them (thus Pekin and Petralona grouped in certain dendrograms), since the analysis weighted the sets by size and small centroid shifts were greatly magnified in large sets because of the large value of n for the set. Thus the cluster analyses were to some extent size dependent, but the inclusion of groups in the analyses were not arbitrary since the fossil groups were the only ones available. The modern groups, it could be argued, were an arbitrary choice, but they were in fact selected to represent the maximum morphological variation to be found in modern man between the Caucasoid, Mongoloid, Negroid and Australoid populations and were essential to the study. As a test two cluster analyses (from Analyses 8 and 13) were recalculated, omitting the recent groups, but the basic pattern of clustering remained unchanged, demonstrating the stability of the method in these examples. It must be emphasised that the dendrograms were not being used for taxonomic purposes here, since most of the fossils were already recognised as belonging to the species Homo sapiens, but it was hoped that they would provide a simple pictorial description of the large D^2 matrices and perhaps demonstrate to what extent groupings such as "modern" or "Neanderthal" were reflected in the pattern of the generalised distances.

Some workers have advised caution in the use of multivariate statistical methods. Marshall's criticisms (1969) are discussed elsewhere with the answer to them provided by Howells (1969c). Kowalski (1972) stated that complicated functions often obscured information rather than clarified it, and tests of significance associated with the

T^2 or D^2 statistics often revealed a marked loss of power compared with testing of individual measurements by Student's t-test. Furthermore, assumptions of normality, equality of covariance matrices etc. were not always justified in anthropological data (but see van Vark, 1970). In addition Kowalski considered that description and communication of the information contained in multidimensional data was much more difficult than was the case with results gained by simpler techniques. He concluded that "nobody questions the use of multivariate techniques when they can add something to the results of simpler analyses, but everyone should question their use when they impede a communication among anthropologists and focus attention on mathematical artefacts instead of on biological truths. A handy rule of thumb is suggested by Koons' (1962) observation that 'we can hardly defend our model if we cannot interpret the results it provides'" (Kowalski, 1972, page 128).

The criticisms of Oxnard (1972a) were directed not so much at multivariate techniques, in which he still had much confidence (Oxnard, 1972b), but at the ways in which they have been applied in some cases. As an example he criticised the way in which Day (1967) and Day and Wood (1968, 1969) interpolated fossil foot bones into a matrix derived from measurements of the foot-bones of modern apes and man. Plots of the first two canonical variates alone gave misleading results compared with those obtained using the matrix of generalised distances. Hence Oxnard advised greater caution in the use of canonical variates analyses, and suggested that fossil forms should in future be included directly in initial computations of multivariate statistical analyses, not interpolated after the analysis has already

produced loading factors derived from extant forms. This procedure has, in fact, been adopted in the present study.

CHAPTER THREE: RESULTS

(i) Introductory remarks

The results section has been arranged to display firstly graph plots of parietal indices and angles (figures 1-6), and secondly details of the fourteen multivariate analyses performed and graph plots and dendrograms derived from them (figures 7-50). In most cases the names of variables or crania have been represented in abbreviated form as listed in Chapter 2, and the variable abbreviations are also reproduced on the book-mark provided with this thesis.

The first graph figured (figure 2) is a plot of four parietal measurements including one measurement not employed in the multivariate analyses (bregma-asterion chord). This graph has been included as it provided information about the Kanjera and Ehringsdorf material, which was otherwise too fragmentary to use in the corresponding multivariate analysis of parietal bone measurements. Kanjera was shown to be outside the range of anatomically modern populations in the plot of these measurements, whereas Ehringsdorf was probably within the range of both Neanderthal and modern populations.

The cranial angles employed in the present study were those which could be computed with some certainty in the fossil specimens. Thus angles such as the simotic or dacryal angles (Howells, 1973) have been omitted because these regions were generally not well preserved. The frontal, parietal and occipital angles were not included since they were computed using essentially the same variables as the corresponding multivariate analyses and duplicated the multivariate results. In the angle plots (figures 3-6), mean values have been added for male and

female populations of Norse, Zulu, Tasmanian and Eskimo (see figure 1) taken from data provided by Howells (1973).

The results of the multivariate analyses are presented in the following order: variables and sample of crania used; corrected generalised distances (D^2) matrix; graphs from the D^2 matrix; dendrogram from the D^2 matrix; relative contributions of variables to the D^2 distances using Pekin, Neanderthal and Upper Palaeolithic groups as reference populations; plot of canonical variate 1 against 2. The D^2 matrices contain the corrected generalised distances, significant at the 5% level except where indicated by N.S. Those D^2 values marked by an asterisk were significant when tested at the 5% level but not at the 1% level. The relative contributions of variables to the uncorrected D^2 distances have been computed using the coefficients of separate determination (Hope, 1968). Up to six variables are listed in order of importance, and the + or - sign preceding the variable abbreviation indicates whether the measurement of the variable in question was greater or less in the reference population (Pekin, Neanderthal or Upper Palaeolithic) than in the fossil or group compared. Thus in the frontal bone analysis (analysis 1), it can be seen that the Pekin crania were differentiated from the Solo crania primarily by a lower bistephanic breadth and then a higher supraorbital projection, lower frontal chord, lower frontal (nasion-subtense) fraction and a higher frontal (nasion) subtense. An asterisk by a fossil or group indicates that the D^2 value in question was not significant at the 5% level.

As a means of graphically representing the D^2 results various graphs were drawn using two selected populations as reference axes, against which the other groups were plotted. With only two D^2 values considered the graphs were not totally accurate representations of the whole matrix, and could not depict distances between the other groups plotted. Nevertheless by carefully selecting a Homo erectus, Neanderthal or modern group as the reference population, it was possible to gain a good general impression of the degrees of affinity of various crania to each other. It could be argued that the square root of the D^2 distances (D) should have been used as a linear measurement, but in fact where this was used (for example figure 48) the graph did not differ appreciably from one drawn using D^2 values (cf. figure 47).

To produce the dendrograms illustrated here, an agglomerative clustering method was employed as explained in Chapter 2. The dendrograms should be viewed as supplementary to examination of the complete D^2 matrices since they provided a convenient but simplified picture of the generalised distances obtained in each analysis. The clusterings were ordered by using the square root of the total mean square distance at each level to provide a linear scale, and this has been drawn alongside the dendrograms. Such a scale also provided some measure of the relative compactness of the groups formed at each level.

In view of the large number of canonical variates generated in most analyses, a plot of the first two canonical variates could not represent the total picture of group relationships in multidimensional space.

In all analyses conducted here, the first three canonical variates were significant when tested using the method described by Seal (1964), and in analyses with large numbers of variables the number of significant canonical variates often exceeded ten. Because of limitations of time and space it was impractical to plot all significant canonical variates, and the Mahanolobis D^2, although perhaps more difficult to interpret, gave single concise valucs of the generalised distances, without the problems inherent in canonical variates analyses (Oxnard, 1972a). For this reason the Mahanolobis D^2 was selected as the primary method to be used in the present investigation. Nevertheless canonical variates analysis can provide amplification of the generalised distances and plots of canonical variates aided interpretations of relationships between the groups analyses.

Normally canonical variates are plotted using equiprobability circles around group mean values to represent a given amount of population variability (e.g. to enclose 90% or 95% of the population considered). Such circles are useful where small numbers of groups are plotted and where the first two canonical variates contain most of the information about group distributions, or can be related to functional criteria. In the present study with large numbers of populations this procedure has not been adopted as the large number of circles to be drawn would cause confusion and additionally could be misleading about the affinities of individual fossils. For example in analysis 14 the first two canonical variates suggested that Petralona and Steinheim

were closely related to the Neanderthal population, and would be contained within a 90% equiprobability circle. However three-dimensional models constructed by the present author demonstrated that when the third or fourth canonical variates were added the picture was very different and these crania were separated from each other by much larger distances. In fact the equi-probability circles, if drawn to contain 95% of the population variability, would have radii of $\sqrt{5.991}$ (= 2.447) units for a two-dimensional graph plot (this is equivalent to χ^2 for two degrees of freedom at the 5% probability level).

Fig. 1

Symbols used in graphs.

Symbols Used in Graphs

△	Pekin	1	Norse
▲	Solo	2	Zulu
*	Neanderthal	3	Eskimo
0	Upper Palaeolithic	4	Tasmanian
•	Mesolithic	X	Others

Fig. 2

Graph plot of parietal indices calculated for the fossil material. PAS = parietal subtense; PAC = parietal (bregma-lambda) chord; BAC = bregma asterion chord; ASB biasterionic breadth

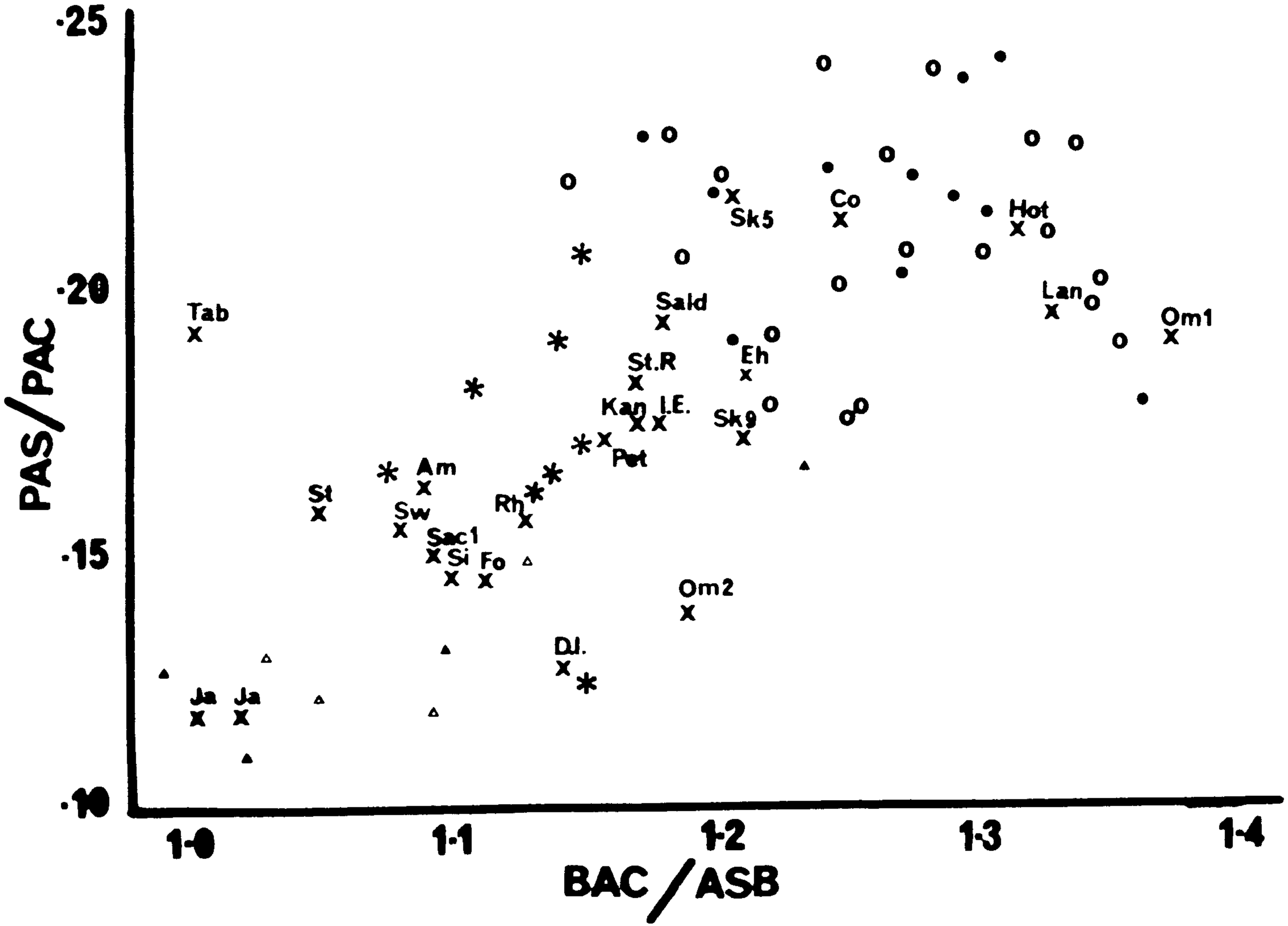

·25
·20
·15
·10
PAS/PAC
1·0
1·1
1·2
1·3
1·4
BAC/ASB
Tab
Sald
St.R
Eh
Kan
I.E.
Skg
Pet
Am
St
Sw
Rh
Sac1
Si
Fo
Om2
D.I.
Ja
Ja
Sk5
Co
Hot
Lan
Om1

Fig. 3

Diagram showing certain cranial angles used in the present study

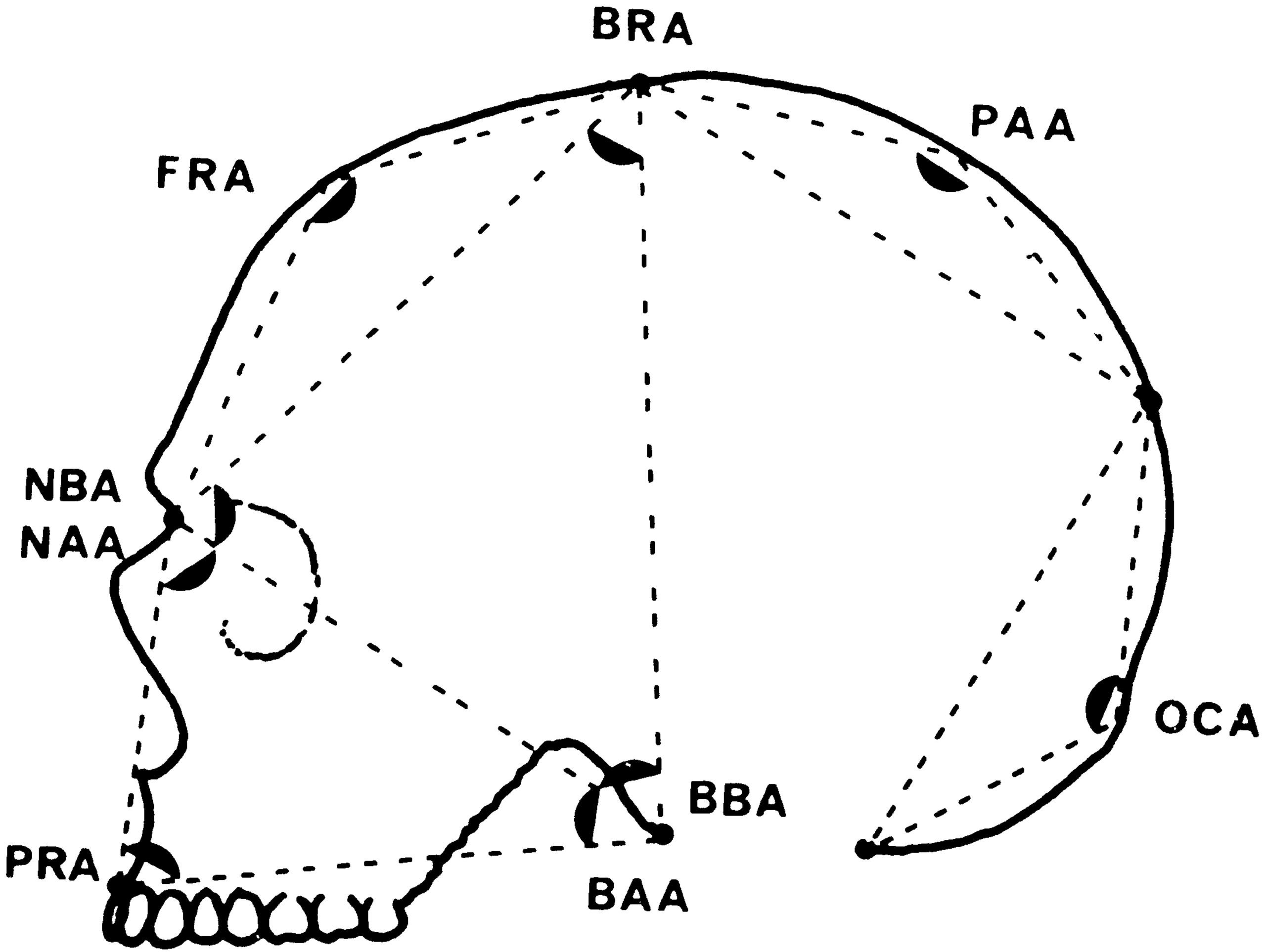

BRA
FRA
PAA
NBA
NAA
BBA
PRA
BAA
OCA

Fig. 4

Graph showing values of the zygomaxillary and nasio-frontal angles of crania studied

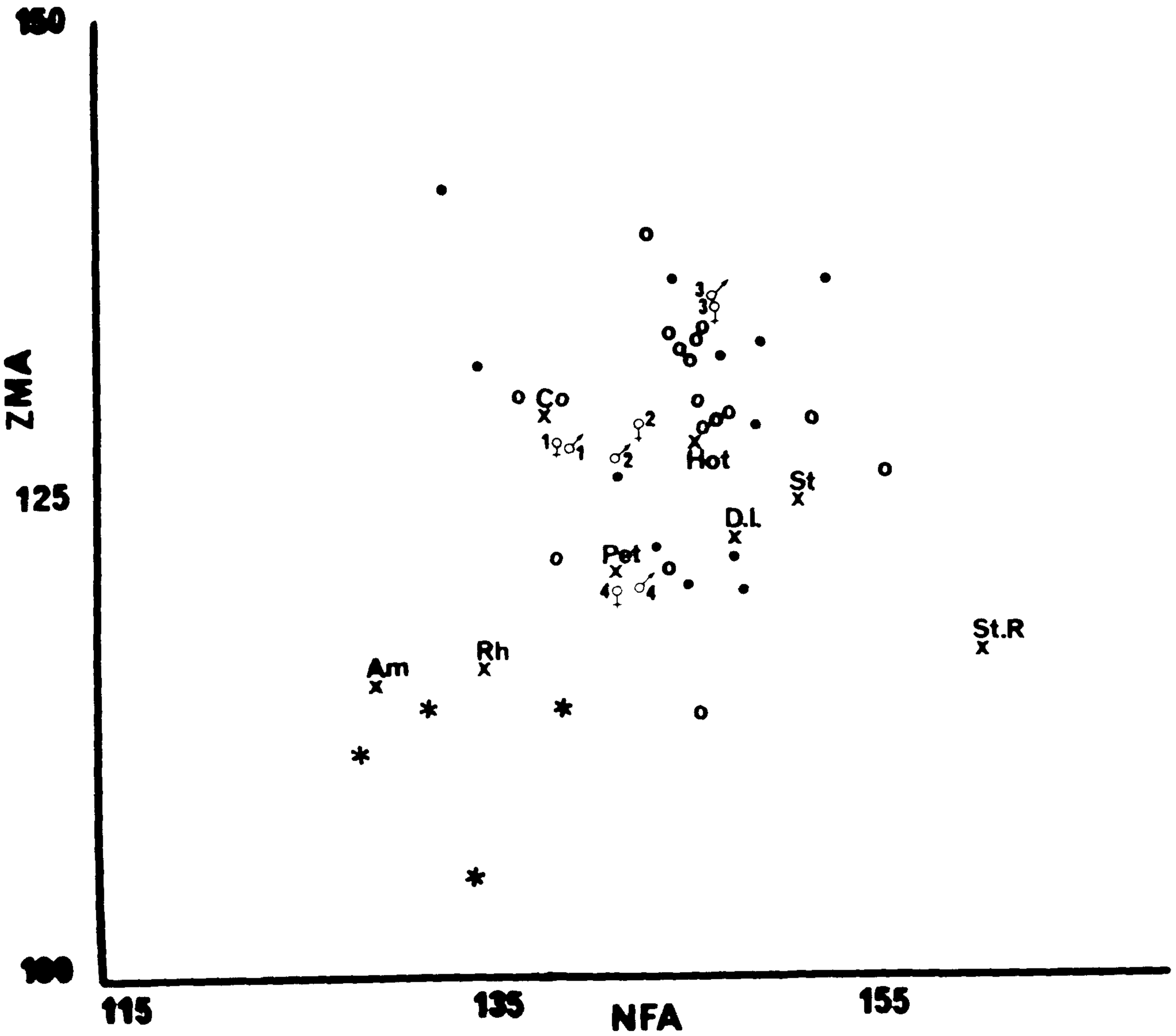

150
ZMA
125
100
115
135
155
NFA
Co
Hot
St
D.L
Pet
Rh
Am
St.R

Fig. 5

Graph showing values of the basion (NA-PR) and prosthion (NA-BA) angles of crania studied

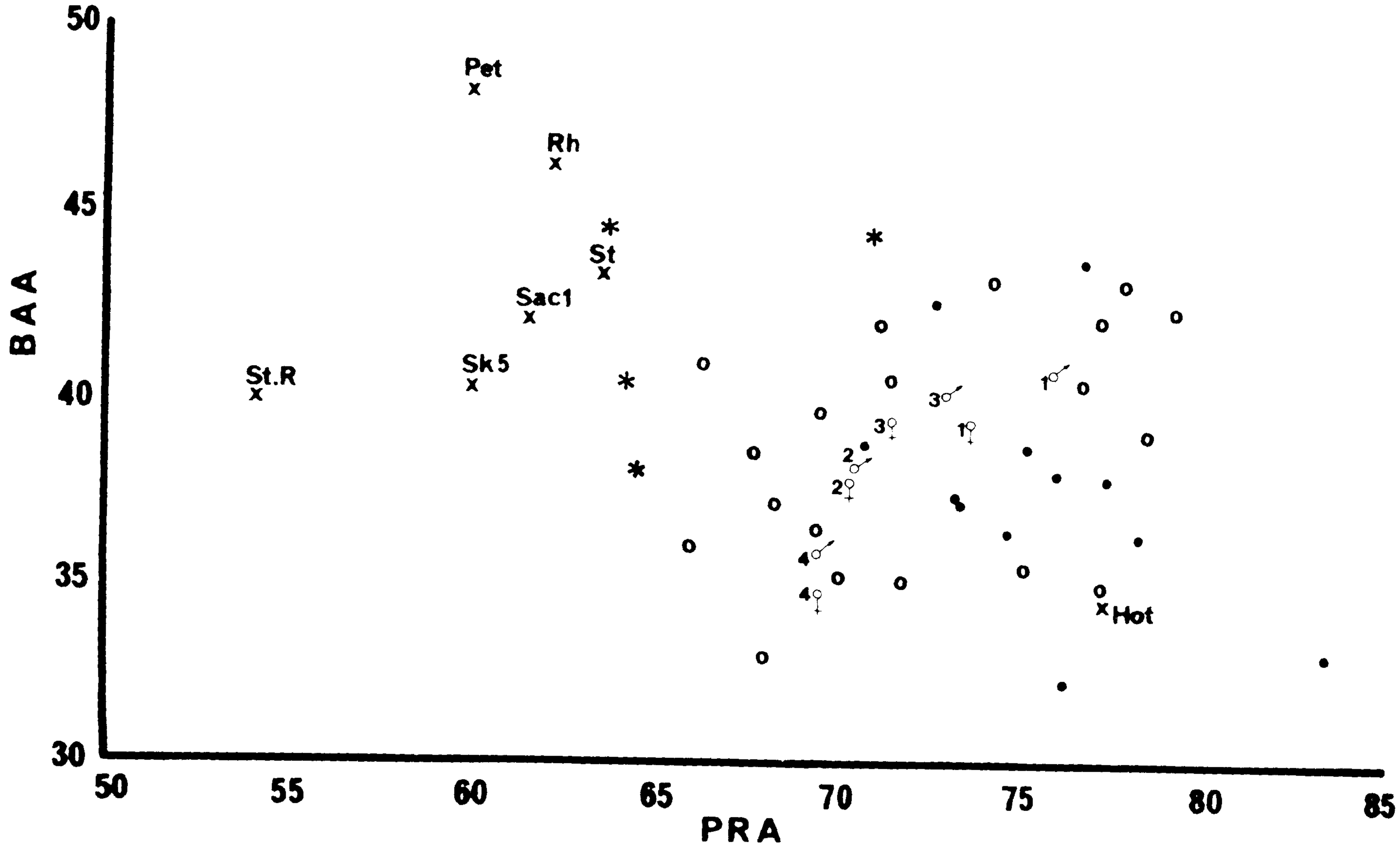
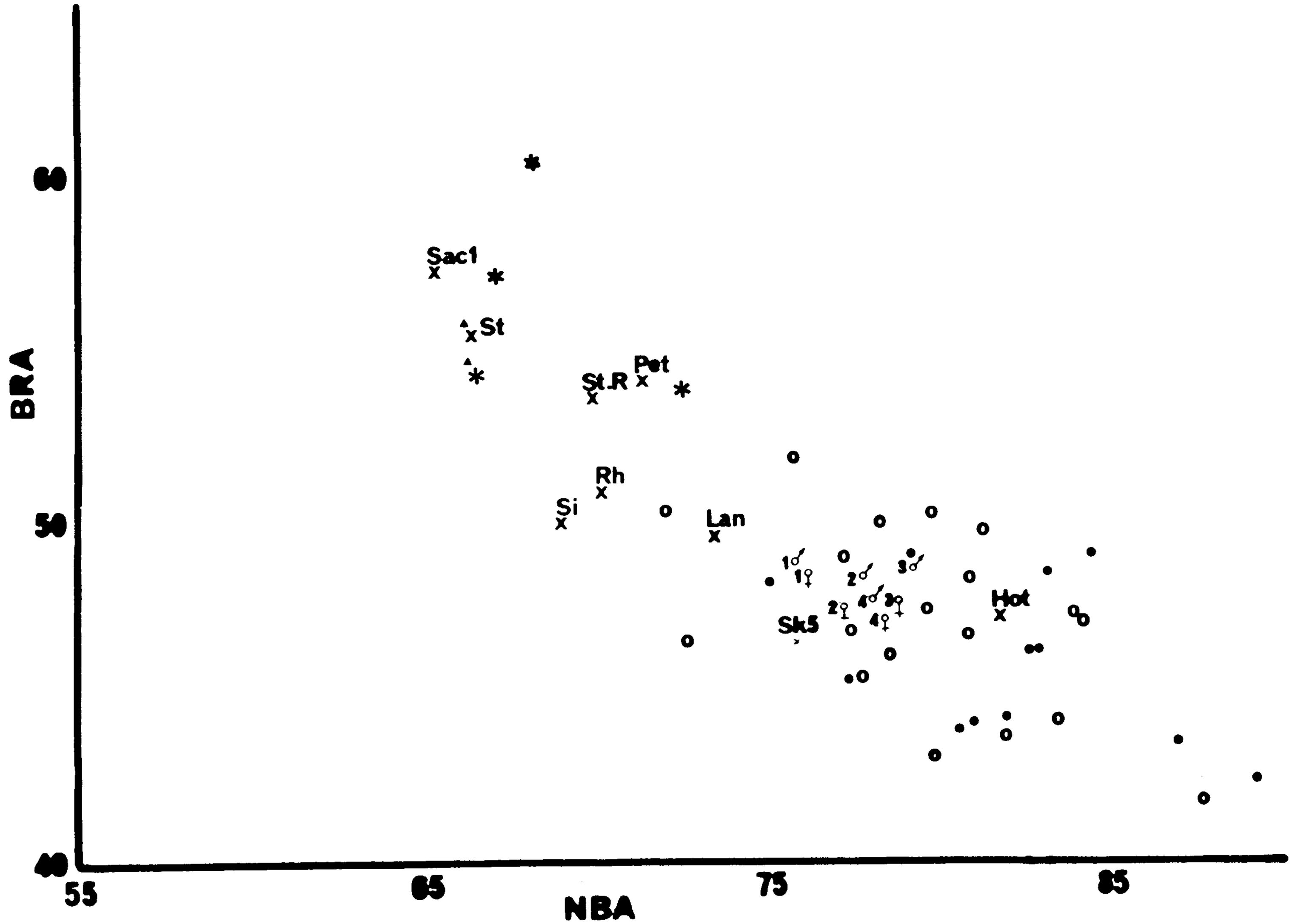

50
45
40
35
30
BAA
50
55
60
65
70
75
80
85
PRA
Pet
Rh
St
Sac1
St.R
Sk5
Hot
1
2
3
4

Fig. 6

Graph showing values of the bregma (NA-BA) and nasion (BA-BR) angles of crania studied


BRA
60
50
40
55
65
75
85
NBA
Sac1
St
St.R
Pet
Rh
Si
Lan
Hot
Sk5
1♂
1♀
2♂
3♂
2♀
4♂
3♀
4♀

(ii) Analysis 1 Frontal bone (Figs 7 - 9)

Variables used (5)

STB, SOS, FRC, FRS, FRF

Sample

Pekin	E, L.1, L.2, L.3.	(4)
Solo	1, 5, 6, 11	(4)
Neanderthal	Sp.1, 2, N.V., Sala, M.C., L.Ch., Qu., Gi, Mo, Fe.	(10)
Middle-east Neanderthals	Ga, Am, Tab.	(3)
Skhūl	Sk.5	(1)
Saccopastore	Sac. 1	(1)
Krapina	Kr.E	(1)
Upper Palaeolithic	En, Pr.3, 4, Br. 1, 2, 3, Ob. 1, 2, D.V. 2, 3, Lau 1, Or, Ma, S.T. 3, 4, A.C. 1, 4, 6, Gri, Ch, Cr. 1, 2, 3, Ko, L.B. 2, L.R., C.C., Lan, G.C., F.J.	(30)
Mesolithic	Hoh 1, 2, Kau, Of 2, 11, 25, Af 9, 10, 29, 32, Te. 1, 11, Taf 11, 17, Gra.	(15)
Modern populations	No (110), Zu (102), Tas (86), ES (108)	
Individual cases	Co, Pet, D.I., Hot, Rh, Om 1, 2, Po, Si, Eh, Sald, I.E., St.R.	

TABLE 1 Matrix of generalised distances (D^2)

Analysis 1 - frontal bone

24.83										
I.S.	42.73									
5.52	N.S.	19.13*								
2.43	N.S.	23.11	N.S.							
4.18*	N.S.	25.54	N.S.	N.S.						
.S.	20.03*	N.S.	N.S.	12.75*	N.S.					
.S.	32.12	N.S.	26.09	25.76	17.51*	N.S.				
.S.	15.95	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.			
.22	N.S.	46.79	N.S.	N.S.	N.S.	29.55	47.48	N.S.		
S.	38.52	29.85	60.39	47.9	35.35	19.95*	N.S.	24.17	60.49	
I.	Hot	Rh	Om 1	Om 2	Po	Si	Eh	Sald	I.E.	St.R.

Pek															
So	5.52														
Nea	4.95	2.98*													
M.E.N.	7.57	7.53	N.S.												
Sk.5	9.15*	7.92*	9.74*	N.S.											
Sac 1	9.95*	N.S.	N.S.	N.S.	N.S.										
Kr E	13.53	N.S.	10.36*	N.S.	N.S.	N.S.									
U.P.	20.96	11.86	18.93	21.64	N.S.	16.99	29.12								
Me	26.55	13.42	22.37	23.14	N.S.	14.36	25.22	0.96							
No	30.44	16.88	28.20	33.32	11.31	22.97	33.50	2.17	2.58						
Zu	35.52	25.29	34.9	40.37	15.25	32.73	47.60	3.41	5.87	1.72					
Tas	18.72	16.56	24.48	29.35	8.37*	21.86	33.25	3.62	7.35	4.10	3.62				
Es	30.95	24.76	40.07	43.86	10.82	30.31	40.23	6.97	7.35	6.11	6.92	4.80			
Co	48.2	40.96	58.47	56.05	46.23	45.16	32.14	74.42	67.43	85.37	104.85	84.49	71.67		
Pet	12.69	15.39	9.79*	N.S.	N.S.	N.S.	N.S.	36.87	34.73	52.00	63.29	46.65	54.47	28.04	
D.I.	N.S.	10.16*	N.S.	N.S.	N.S.	N.S.	N.S.	21.34	24.19	34.91	39.81	25.84	40.58	57.23	N.S
Hot	24.09	8.07*	20.57	22.28	N.S.	N.S.	17.61*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	53.97	31.
Rh	N.S.	11.64*	N.S.	N.S.	19.68*	15.41*	15.94*	42.34	45.35	59.54	69.84	51.48	64.25	30.74	N.S
Om 1	19.82	N.S.	12.43	19.54	15.83*	26.43	31.27	11.29	13.15	18.09	24.48	23.42	27.43	47.17	31.
Om 2	14.93	N.S.	7.11*	15.13	14.69*	12.20*	12.55*	9.65*	10.23	10.65	19.87	16.68	23.88	49.69	28.
Po	13.62	N.S.	9.23*	13.11*	N.S.	16.25*	27.84	N.S.	N.S.	N.S.	N.S.	N.S.	10.55	63.55	28.
Si	N.S.	N.S.	N.S.	N.S.	N.S.	12.8*	24.05	14.11	18.92	28.27	31.07	23.02	36.21	59.33	N.S
Eh	10.91*	14.84	N.S.	N.S.	N.S.	N.S.	14.67*	27.96	30.40	43.52	48.98	37.45	54.78	66.60	N.S
Sald	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	17.51	20.40	25.36	34.50	22.08	34.67	38.78	N.S
I.E.	23.1	N.S.	20.24	32.36	24.07	23.77	23.98	10.78	12.53	6.26	13.51	11.60	17.46	68.57	52.
St.R.	17.6	31.57	18.11	8.42*	N.S.	N.S.	17.47*	33.91	36.18	45.34	48.02	32.72	49.65	91.20	N.S
	Pek	**So**	**Nea**	**M.E.N.**	**Sk.5**	**Sac 1**	**Kr.E**	**U.P.**	**Me**	**No**	**Zu**	**Tas**	**Es**	**Co**	**Pet**

Fig. 7

Analysis 1 (Frontal bone). Graphical representation of generalised distances (D^2) for fossil and recent material. Eskimo and Pekin populations as reference axes.

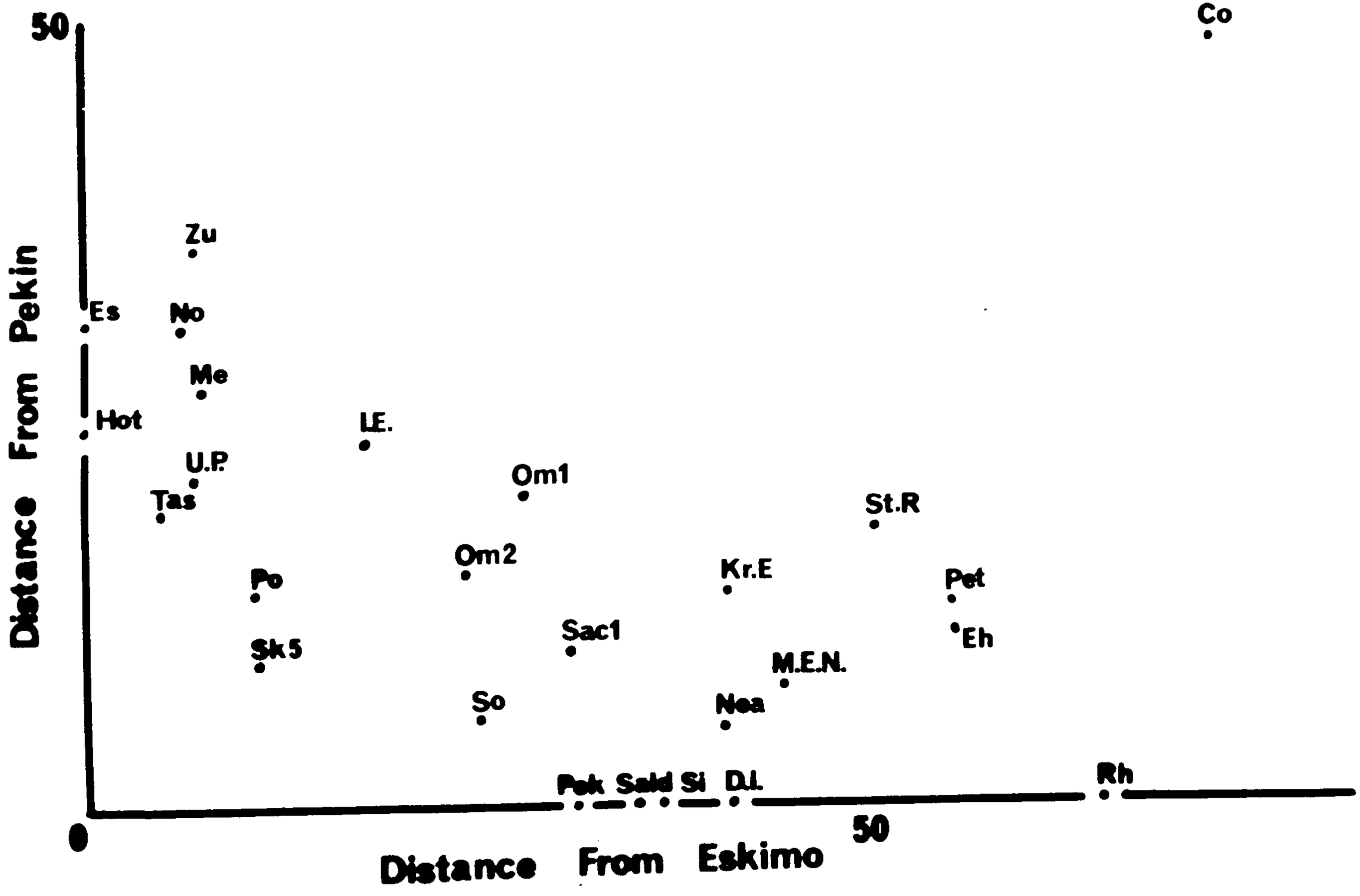
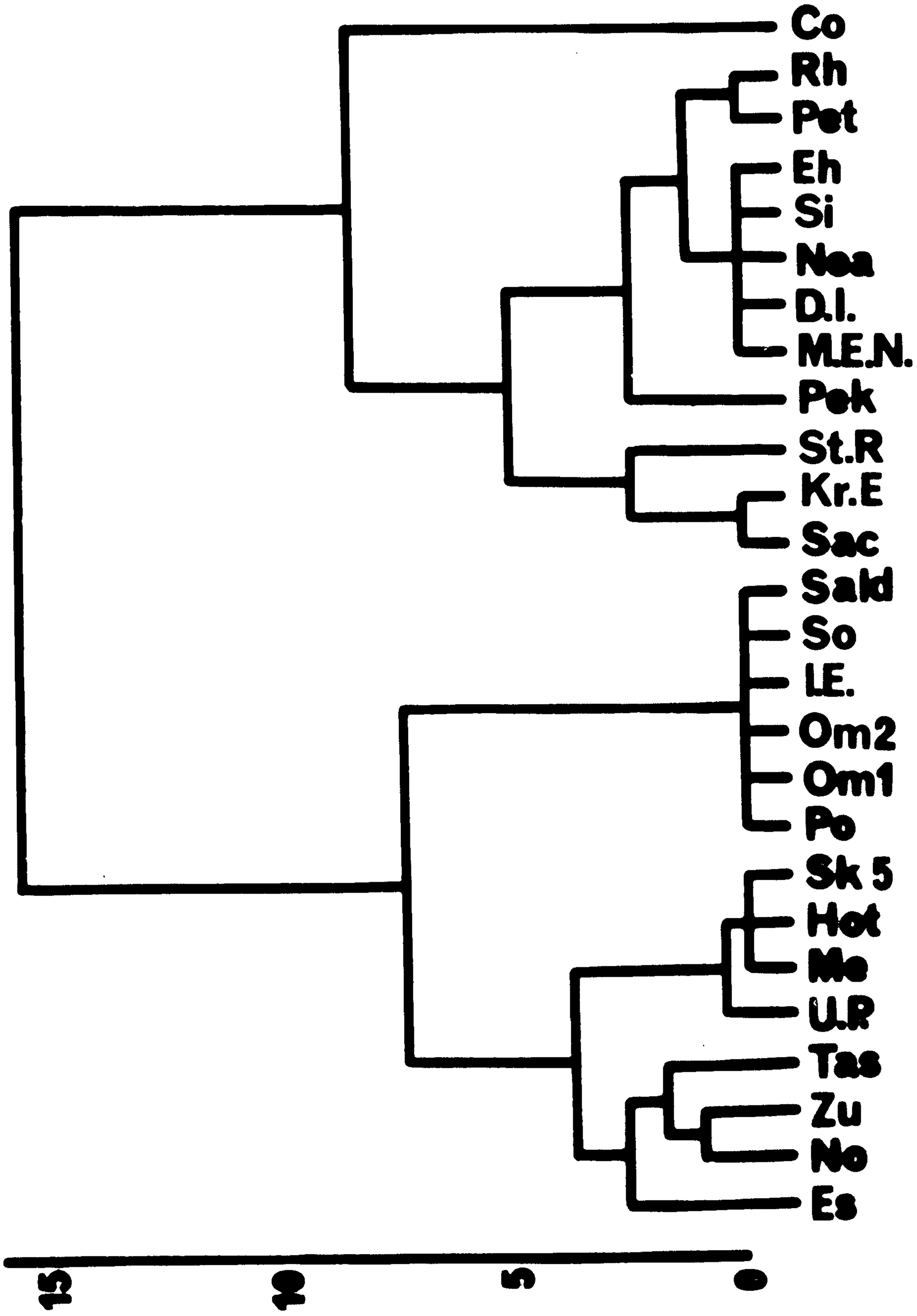

50
Distance From Pekin
Zu
Es
No
Me
Hot
I.E.
U.P.
Om1
Tas
St.R
Om2
Kr.E
Pet
Po
Sac1
Eh
Sk5
M.E.N.
So
Nea
Pek
Said
Si
D.I.
Rh
0
50
Distance From Eskimo
Co

Fig. 8

Analysis 1 (Frontal bone). Dendrogram from generalised distances (D^2) matrix.


Co
Rh
Pet
Eh
Si
Noa
D.I.
M.E.N.
Pek
St.R
Kr.E
Sac
Sald
So
L.E.
Om2
Om1
Po
Sk 5
Hot
Me
U.R
Tas
Zu
No
Es
15
10
5
0

Analysis 1 Frontal bone

Contributions of variables to D^2 analysis in order of importance

Distance from Pekin.

Solo	-STB	+SOS	-FRC	-FRF	+FRS
Neanderthal	-STB	-FRF			
Middle-east Neanderthals	-STB	-FRF	+FRC	-FRS	-SOS
Skhūl	-FRS	+SOS	-STB	-FRF	+FRC
Saccopastore	+FRC	-STB	+SOS	-FRF	
Krapina	+FRC	-FRF	+FRS	+SOS	-STB
Upper Palaeolithic	+SOS	-STB	-FRS	+FRF	-FRC
Mesolithic	+SOS	-STB	-FRS	-FRF	
Norse	+SOS	-STB	+FRF	-FRS	
Zulu	+SOS	+FRF	-STB	-FRS	
Tasmanian	+SOS	+FRF	-FRS	-STB	
Eskimo	+SOS	-FRS	+FRF		
Cohuna	-FRF	+SOS	+FRS	+STB	-FRC
Petralona	-FRF	-STB	-SOS	-FRS	+FRC
Djebel Irhoud*	-STB	+FRC	-FRS	-FRF	-SOS
Hotu	+SOS	-STB	-FRS	-FRF	
Rhodesian*	-FRF	-SOS	-STB		
Omo 1	-FRC	-STB	+SOS		
Omo 2	-STB	+SOS	-FRC	+FRS	
Podkumok	-STB	+SOS	-FRS	-FRC	
Singa*	-STB	-FRS	-FRF	-SOS	
Ehringsdorf	-STB	-FRS	-SOS	-FRF	+FRC
Saldanha*	-STB	+FRS	-FRC	-FRF	
Iwo Eleru	+SOS	-STB	+FRS	-FRC	+FRF
Steinheim reconstruction	+FRC	-FRS	-STB		

Analysis 1 Frontal bone (contd.)

Distance from Neanderthal

Pekin +STB +FRF

Solo +SOS -FRC +STB +FRS -FRF

Middle-east Neanderthals* +FRC -FRF -FRS -SOS -STB

Skhūl -FRS +SOS +FRC +STB -FRF

Saccopastore* +FRC +SOS -FRF +STB

Krapina +FRC -FRF +SOS +FRS +STB

Upper Palaeolithic +SOS -FRS +FRF +STB -FRC

Mesolithic +SOS -FRS +STB

Norse +SOS +FRF -FRS +STB

Zulu +SOS +FRF -FRS +STB

Tasmanian +SOS +FRF +STB -FRS

Eskimo +SOS +STB -FRS +FRF

Cohuna -FRF +STB +SOS -FRC +FRS

Petralona -FRF +FRC +STB -SOS

Djebel Irhoud* +FRC -FRS +STB -SOS -FRF

Hotu +SOS -FRS -FRF +STB -FRC

Rhodesian* -FRF -SOS +STB -FRC

Omo 1 -FRC +SOS -STB

Omo 2 +SOS -FRC +FRS -STB

Podkumok +SOS -FRS -FRC +FRF

Singa* -FRS -FRC -SOS -FRF

Ehringsdorf* -FRS -SOS -FRF +FRC -STB

Saldanha* +FRS -FRC +STB +SOS -FRF

Iwo Eleru +SOS +FRF +FRS -FRC

Steinheim reconstruction +FRC +STB -FRS

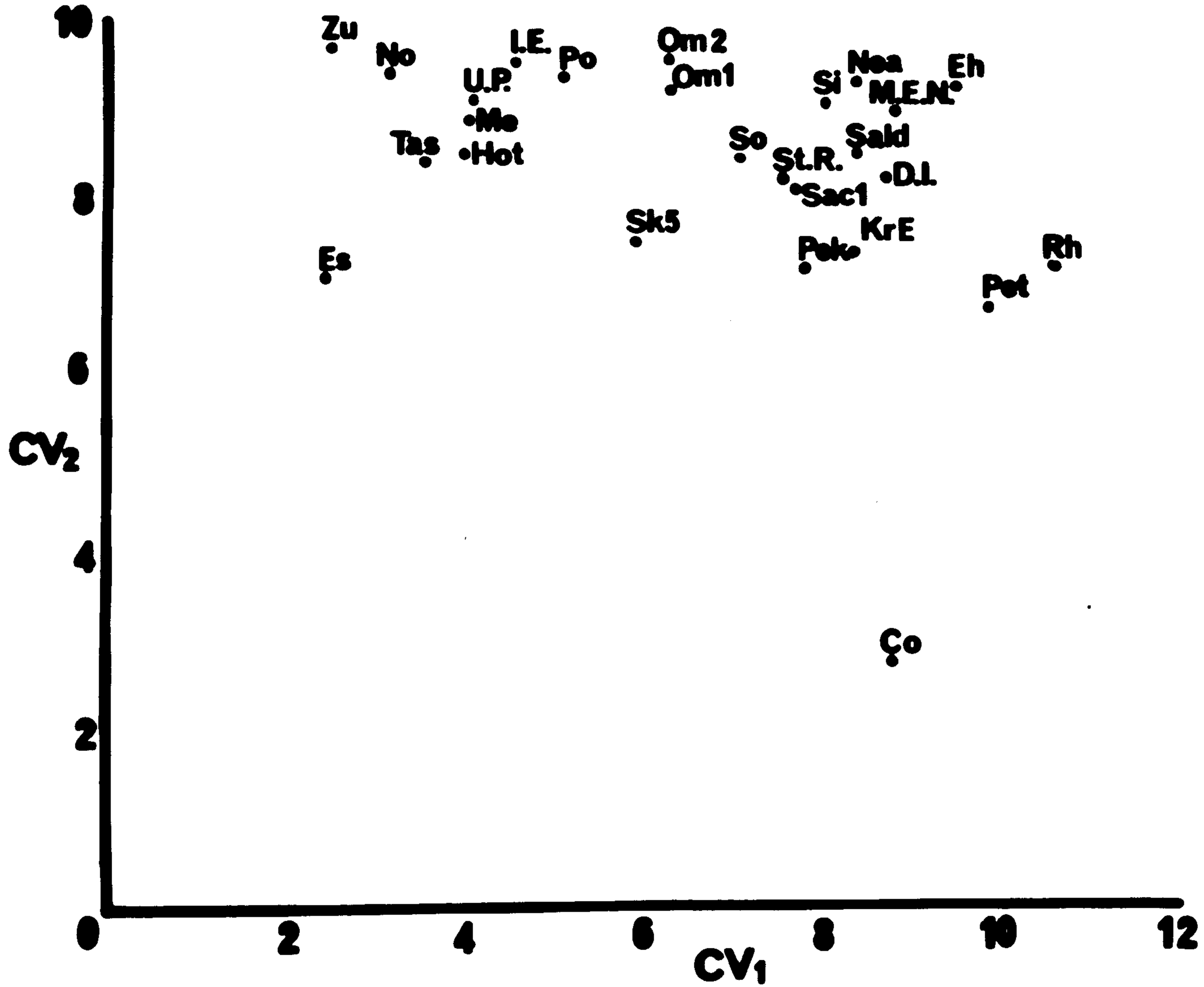
Analysis 1 Frontal bone (contd.)

Distance from Upper Palaeolithic

Pekin	-SOS	+STB	+FRS	-FRF	+FRC
Solo	+FRS	-SOS	-FRF	-FRC	+STB
Neanderthal	-SOS	+FRS	-FRF	-STB	+FRC
Middle-east Neanderthals	-SOS	-FRF	+FRC	+FRS	-STB
Skhūl*	-FRF	+FRC	-SOS	+STB	
Saccopastore	+FRC	-FRF	-SOS	+FRS	
Krapina	+FRS	-FRF	+FRC	-SOS	+STB
Mesolithic	-FRF	+SOS	+FRC	-STB	+FRS
Norse	+SOS	+FRS	+FRF		
Zulu	+FRF	+SOS	-FRS		
Tasmanian	+STB	+FRF	+FRS		
Eskimo	+STB	+SOS			
Cohuna	-FRF	+STB	+FRS	-SOS	-FRC
Petralona	-FRF	-SOS	+FRC	+STB	+FRS
Djebel Irhoud	-SOS	+FRC	-FRF	+STB	
Hotu*	-FRF	+SOS	+FRS	+FRC	
Rhodesian	-SOS	-FRF	+FRS	+STB	
Omo 1	-FRC	-SOS	-FRF	+FRS	-STB
Omo 2	+FRS	-FRC	-STB	-SOS	
Podkumok*	-FRC	-SOS	-STB		
Singa	-SOS	-FRF			
Ehringsdorf	-SOS	-FRF	+FRC	-STB	
Saldanha	-SOS	+FRS	-FRF	-FRC	+STB
Iwo Eleru	+FRS	+SOS	+FRF	-FRC	
Steinheim reconstruction	+FRC	-SOS	+STB		

Fig. 9

Analysis 1 (frontal bone). Plot of canonical variates 1 and 2 for fossil and recent material.


Zu
No
I.E.
U.P.
Me
Tas
Hot
Po
Om2
Om1
Si
Nea
M.E.N.
Eh
Şald
So
St.R.
D.I.
Sac1
Sk5
KrE
Pek
Es
Rh
Pot
Ço
CV2
CV1
0
2
4
6
8
10
12

Analysis 2 Parietal bones (Figs 10-12)

Variables used (5)

XCB, ASB, PAC, PAS, PAF

Sample

Pekin E, L.1, L.2, L.3 (4)

Solo 1, 5, 6, 10, 11 (5)

Neanderthal Sp.1, 2, M.C, L.Ch, Qu, Gi, Mo, Fe (8)

Middle-east Neanderthals Am, Tab (2)

Skhūl Sk.5, 9 (2)

Saccopastore Sac 1 (1)

Upper Palaeolithic En, Pr. 3, 4, Br. 1, 2, 3, Ob 1, 2, Stt, Lau 1, 5, D.V. 3, Or, S.T.3, A.C. 1, 4, 6, Gri, Ch, Cr. 1, 2, 3, Ko, L.B.2, L.R., C.C., Lan, G.C., F.J. (29)

Mesolithic Hoh 1, 2, Kau, Of 2, 11, 25, Af 9, 10, 29, 32, Te 1, 11, Taf 11, 17, Gra (15)

Modern populations No (110), Zu (102), Tas (86) Es (108)

Individual cases Co, Pet, Fo, D.I., Hot, Rh, Om 1, 2, Sw, Si, Ja. 2, Sald., St., I.E., St.R.

Pek											
So	N.S.										
Nea	5.86	3.54									
M.E.N.	4.69*	N.S.	N.S.								
Sk.	14.39	12.22	3.93*	N.S.							
Sac 1	N.S.	N.S.	N.S.	N.S.	N.S.						
U.P.	32.49	33.43	17.14	19.77	6.29	13.50					
Me	32.73	33.20	15.17	19.87	6.92	13.13	N.S.				
No	25.26	27.95	12.64	17.85	8.74	10.10*	4.26	2.02			
Zu	32.74	39.24	21.98	28.37	14.06	16.20	3.51	3.05	2.45		
Tas	28.17	32.88	16.95	20.93	6.71	15.06	3.00	2.49	2.03	1.65	
Es	27.52	32.60	18.61	21.02	8.29	14.20	2.77	3.17	2.54	1.21	0.60
Co	27.65	31.43	18.57	16.88	N.S.	15.60*	N.S.	N.S.	N.S.	N.S.	N.S.
Pet	9.70*	N.S.	N.S.	N.S.	N.S.	N.S.	16.35	12.50	11.07	21.59	17.98
Fo	12.50*	8.64*	N.S.	N.S.	12.85*	N.S.	17.48	18.09	21.11	26.79	26.99
D.I.	13.68	13.45	9.30*	11.71*	9.28*	N.S.	23.53	26.19	31.41	34.22	29.18
Hot	36.63	41.66	21.62	29.94	15.6	14.48*	N.S.	N.S.	N.S.	N.S.	N.S.
Rh	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	12.13	14.32	16.64	22.15	19.17
Om 1	26.44	24.06	N.S.	15.86	9.37*	N.S.	N.S.	N.S.	N.S.	9.56*	10.30
Om 2	22.73	18.46	19.02	15.27	20.47	N.S.	23.56	28.48	35.23	37.07	37.74
Sw	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	12.93	13.85	13.29	19.86	16.94
Si	N.S.	N.S.	N.S.	N.S.	24.19	N.S.	43.41	38.45	29.28	45.04	40.87
Ja	N.S.	8.36*	13.51	16.63	27.35	N.S.	44.82	42.92	28.99	36.34	33.13
Sald	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
St.	N.S.	N.S.	N.S.	N.S.	9.92*	N.S.	21.12	21.39	12.63	18.06	15.35
I.E.	9.97*	9.58*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	8.81*	N.S.
St.R.	8.15*	10.49*	8.30*	N.S.	N.S.	N.S.	N.S.	8.73*	8.12*	9.10*	N.S.
	Pek	So	Nea	M.E.N.	Sk.	Sac 1	U.P.	Me	No	Zu	Tas

TABLE 2 Matrix of generalised distances (D^2)

Analysis 2 - parietal bone

N.S.														
20.90	23.71													
25.99	26.35	N.S.												
30.93	25.82	N.S.	N.S.											
N.S.	N.S.	18.27*	21.18	34.98										
17.63	13.77*	N.S.	N.S.	N.S.	20.24									
12.34	15.09*	N.S.	N.S.	14.3*	N.S.	N.S.								
33.79	29.06	18.57	N.S.	N.S.	31.96	N.S.	18.02*							
15.88	14.14*	N.S.	N.S.	N.S.	18.64*	N.S.	N.S.	N.S.						
42.39	48.86	N.S.	N.S.	25.27	44.14	12.35*	19.26*	32.84	N.S.					
32.97	37.76	17.66*	28.24	30.04	41.93	22.29	37.22	45.62	12.57*	N.S.				
N.S.	N.S.	N.S.	N.S.	12.16*	N.S.	N.S.	N.S.	17.93*	N.S.	N.S.	N.S.			
13.30	13.65*	N.S.	14.23*	20.09	21.15	N.S.	22.08	23.50	N.S.	N.S.	N.S.	N.S.		
7.71*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	13.52*	20.84	N.S.	N.S.	
N.S.	N.S.	15.22*	N.S.	13.46	N.S.	N.S.	16.61*	N.S.	N.S.	27.76	18.56*	N.S.	N.S.	N.S.
Es	Co	Pet	Fo	D.I.	Hot	Rh	Om 1	Om 2	Sw	Si	Ja	Sald	St	I.E St. R

Fig. 10

Analysis 2 (parietal bones). Graphical representation of generalised distances (D^2) for fossil and recent material. Zulu and Java (Homo erectus)as reference axes.

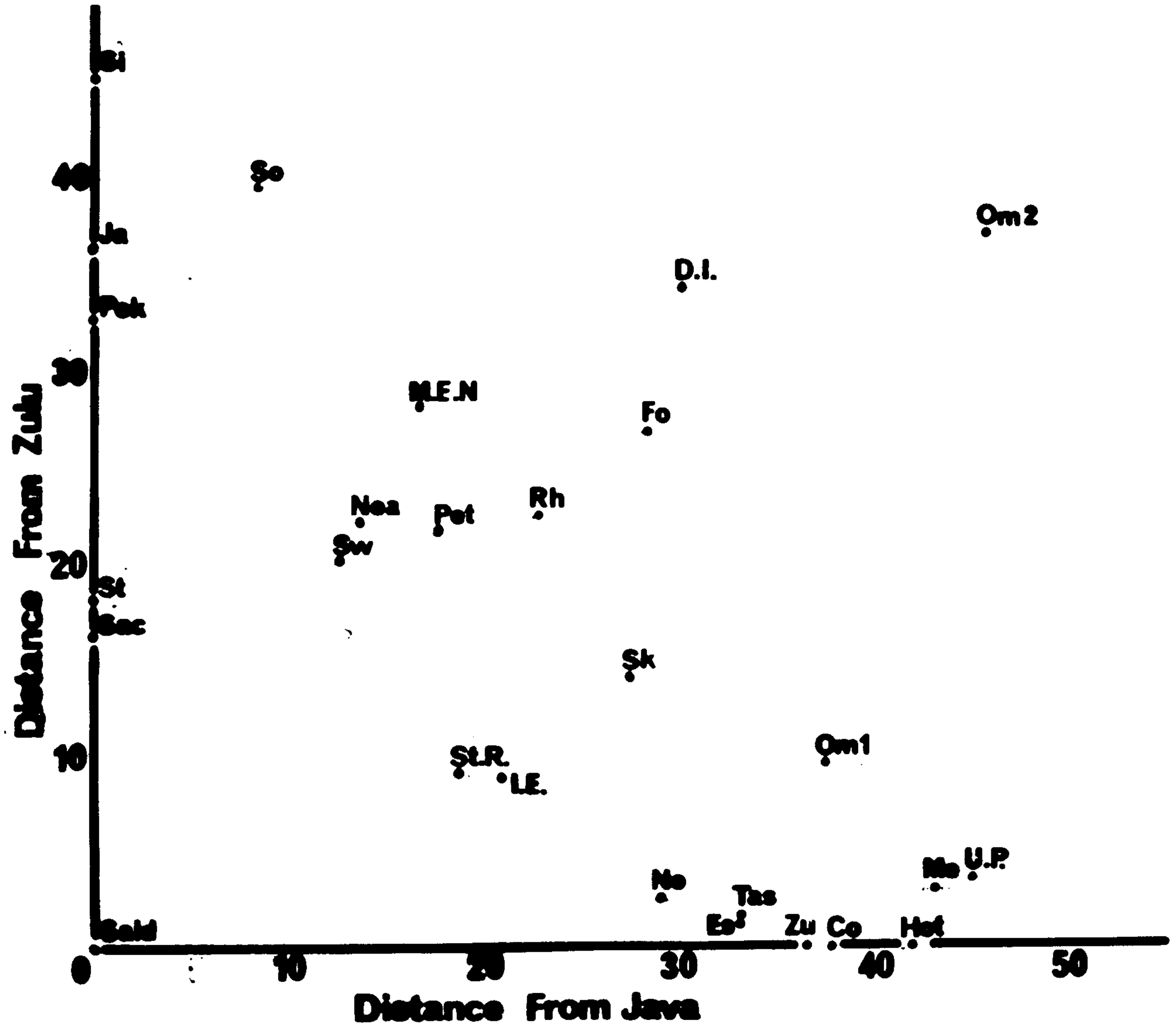

Distance From Zulu
Distance From Java
0
10
20
30
40
50
Ja
Pak
St
Sac
Gold
So
Om2
D.I.
N.E.N
Fo
Nea
Pet
Rh
Sw
Sk
St.R.
L.E.
Om1
Ne
Ths
Es²
Zu
Co
Hot
Ma
U.P.

Fig. 11

Analysis 2 (parietal bones). Dendrogram from generalised distances (D^2) matrix.

Ja
Pe
So
Si
St
St.R
Om2
Fo
D.l.
Pet
Rh
Nea
M.E.N.
Sw
Sac
Sk
Sald
I.E.
Om1
U.P.
Me
Tas
Co
Es
No
Hot
Zu

Analysis 2 Parietals Contribution of variables in order of importance

Distance from Pekin

Solo* -ASB -XCB -PAS -PAF

Neanderthal -PAS -XCB -PAC -PAF

Middle-east Neanderthals -PAS -ASB -PAC -XCB

Skhūl -PAS -PAC -XCB

Saccopastore* -PAF -PAC -PAS -XCB

Upper Palaeolithic -PAS -PAC +ASB -PAF +XCB

Mesolithic -PAS -PAC +ASB -PAF -XCB

Norse -PAS +ASB -PAF

Zulu -PAS +ASB -PAC -PAF +XCB

Tasmanian -PAS +ASB -PAC +XCB

Eskimo -PAS +ASB -PAC +XCB -PAF

Cohuna -PAS -PAC +XCB +ASB

Petralona -XCB -PAS -PAF -PAC

Fontéchevade -PAC -PAF -XCB

Djebel Irhoud -PAC -XCB

Hotu -PAS +ASB -PAF -PAC +XCB

Rhodesian* -PAC -PAF -ASB

Omo 1 -PAF -PAS -PAC -XCB +ASB

Omo 2 -PAC -PAF -ASB

Swanscombe* -PAC -PAF -ASB -PAS

Singa* -XCB -PAF -PAS -ASB

Java 2* +PAC +ASB

Saldanha* -PAS -PAC +ASB -PAF -XCB

Steinheim* -PAS +XCB -PAF +ASB +PAC

Iwo Eleru -PAC -PAS -XCB +ASB -PAF

Steinheim reconstruction -PAC -PAS +XCB

Analysis 2 Parietals (contd.)

Distance from Neanderthal

Pekin +PAS +XCB +PAC +PAF

Solo -ASB +PAS +PAC +XCB +PAF

Middle-east Neanderthals* -ASB +XCB +PAF -PAS -PAC

Skhūl -PAC -PAS +XCB +PAF

Saccopastore* +XCB +PAS -PAF

Upper Palaeolithic -PAC +XCB -PAS +ASB -PAF

Mesolithic -PAS +ASB -PAC +XCB -PAF

Norse -PAS +ASB +XCB -PAF

Zulu +ASB +XCB -PAS -PAC -PAF

Tasmanian +ASB +XCB -PAS -PAC

Eskimo +XCB +ASB -PAS -PAC

Cohuna +XCB -PAS -PAC +ASB +PAF

Petralona* -XCB -PAF

Fontéchevade* -PAF -PAC +PAS -ASB

Djebel Irhoud -PAC +PAS -PAF

Hotu +ASB +XCB -PAF -PAS -PAC

Rhodesian* -PAC +XCB -ASB -PAF +PAS

Omo 1* -PAF -PAC +ASB -PAS -XCB

Omo 2 -PAC +XCB -PAF -ASB +PAS

Swanscombe* +XCB +PAS -ASB -PAC -PAF

Singa* +PAC -XCB -ASB +PAS

Java 2 +PAC +PAS +XCB +ASB +PAF

Saldanha* +XCB -PAS +ASB -PAC +PAF

Steinheim* +XCB +PAC +PAS

Iwo Eleru* -PAC +ASB +XCB

Steinheim reconstruction +XCB -PAC +PAF -PAS

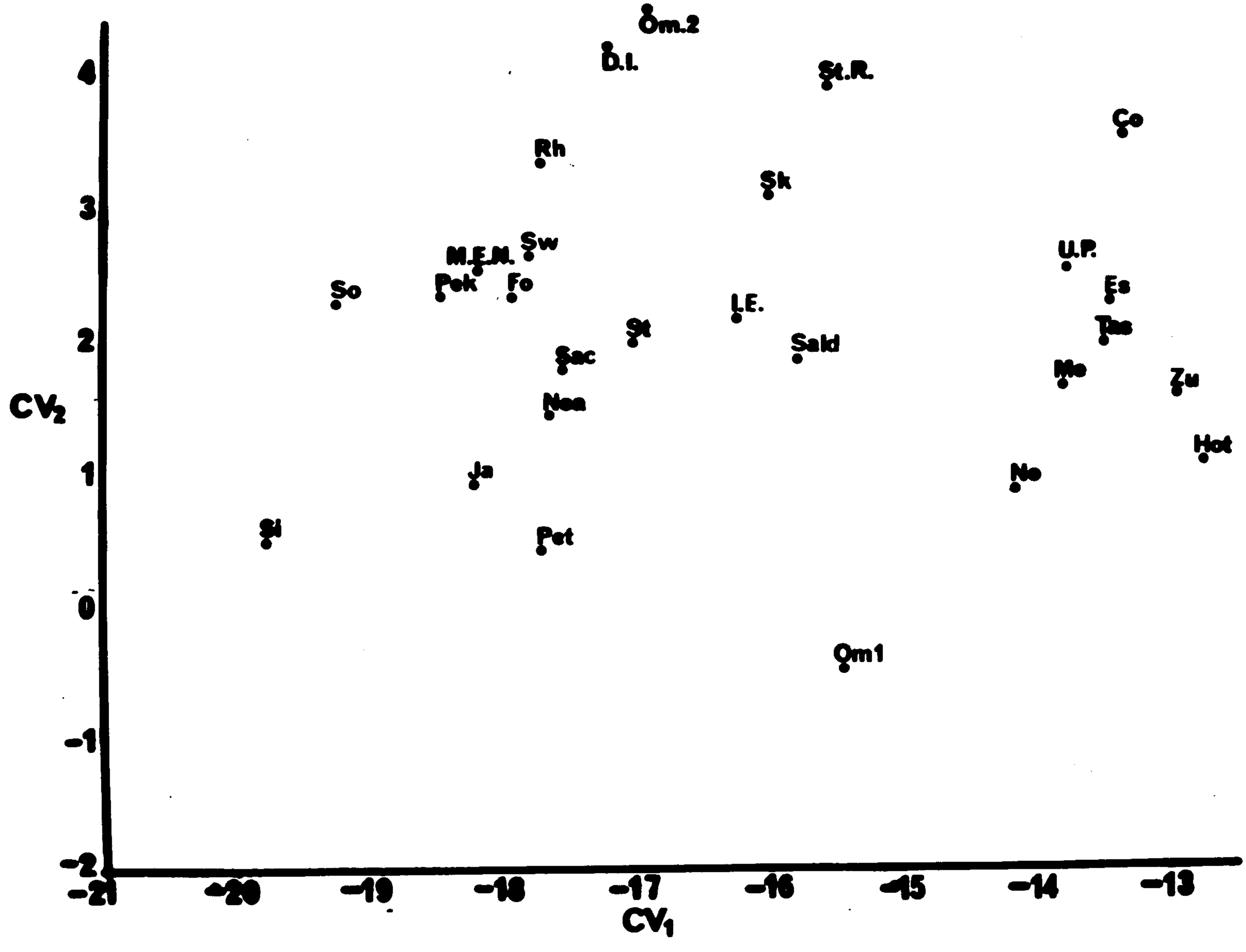
Analysis 2 Parietals (contd.)

Distance from Upper Palaeolithic

Pekin	+PAS	+PAC	-ASB	+PAF	-XCB
Solo	+PAC	+PAS	-ASB	-XCB	+PAF
Neanderthal	+PAC	-XCB	+PAS	-ASB	+PAF
Middle-east Neanderthals	-ASB	+PAC	+PAS	+PAF	-XCB
Skhūl	+PAF	-ASB	-XCB	+PAS	+PAC
Saccopastore	+PAS	+PAC	-ASB	-XCB	
Mesolithic*	-XCB	+PAC	-PAS	+ASB	-PAF
Norse	+PAC	+ASB	-XCB		
Zulu	+ASB	+PAC			
Tasmanian	+PAC	+PAF	+ASB		
Eskimo	+PAC	+XCB	+PAF	+ASB	
Cohuna*	+PAF	+XCB			
Petralona	-XCB	+PAC	+PAS	-ASB	
Fontéchevade	+PAS	-ASB	-XCB	-PAF	+PAC
Djebel Irhoud	+PAS	-XCB	+PAF	-ASB	
Hotu*	+ASB	-PAF	+PAC		
Rhodesian	+PAS	-ASB	+PAC	-XCB	
Omo 1*	-XCB	-PAF	+PAS	+PAC	
Omo 2	+PAS	-ASB	-PAF	-PAC	
Swanscombe	+PAS	-ASB	+PAC	-XCB	
Singa	+PAC	-XCB	+PAS	-ASB	
Java 2	+PAC	+PAS	+PAF		
Saldanha*	+PAC	-ASB	+PAF	-XCB	+PAS
Steinheim	+PAC	+PAS	-ASB	+XCB	+PAF
Iwo Eleru*	+PAS	-XCB	+PAF	-ASB	+PAC
Steinheim reconstruction*	+PAS	+PAF	-ASB	+XCB	+PAC

Fig. 12

Analysis 2 (parietal bones). Plot of canonical variates 1 and 2 for fossil and recent material.


Om.2
D.I.
St.R.
Co
Rh
Sk
Sw
M.E.M.
So
Pek
Fo
I.E.
St
Sald
Sac
U.P.
Es
Tas
Me
Zu
Hot
Noa
Ja
No
Si
Pet
Om1
4
3
2
1
0
-1
-2
CV2
-21
-20
-19
-18
-17
-16
-15
-14
-13
CV1

Analysis 3 Occipital bone (Figs 13-15)

Variables used (4)

ASB, OCC, OCS, OCF

Sample

Pekin E, L.1, L.2, L.3 (4)

Solo 1, 5, 6, 11 (4)

Neanderthal L.Ch., Gi, Fe (3)

Skhūl Sk.5 (1)

Saccopastore Sac. 1 (1)

Upper Palaeolithic En, Pr. 3, 4, Ob. 1, 2, Stt, Neu, Br. 3, D.V.3, Lau 1, Or, S.T.3, A.C.1, 4, 6, Gri, Ch, Cr.1, Ko, C.C., Lan, G.C., F.J. (23)

Mesolithic Hoh 1, 2, Kau, Of 11, 25, Af 9, 29 Te 1, 11, Taf 11, 17, Gra (12)

Modern populations No (110) Zu (102) Tas (86) Es (108)

Individual cases Pet, D.I., Hot, Rh, Om 1, 2, Sw, Ve, Si, I.E., St.R.

TABLE 3 Matrix of generalised distances (D^2)

Analysis 3 - occipital bone

.31								
S.	21.26							
.4	N.S.	14.33						
.91	14.41	N.S.	N.S.					
.11	N.S.	N.S.	12.00*	N.S.				
.94	N.S.	N.S.	N.S.	N.S.	N.S.			
.93	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.		
.07	N.S.	N.S.	17.42*	N.S.	N.S.	N.S.	N.S.	
t	Rh	Om 1	Om 2	Sw	Ve	Si	I.E.	St.R

Pek														
So	N.S.													
Nea	N.S.	N.S.												
Sk.5	N.S.	7.43*	N.S.											
Sac 1	N.S.	N.S.	N.S.	N.S.										
U.P.	21.12	26.70	12.18	N.S.	N.S.									
Me	29.71	34.64	17.86	N.S.	7.97*	N.S.								
No	17.63	25.74	12.20	N.S.	N.S.	0.60	2.60							
Zu	30.00	39.87	23.35	7.01*	11.92	2.51	2.23	2.12						
Tas	16.63	26.03	13.32	N.S.	N.S.	1.71	3.27	0.64	1.51					
Es	25.97	33.63	18.66	N.S.	9.18*	1.00	1.46	1.06	0.68	1.37				
Pet	N.S.	8.22*	N.S.	11.14*	N.S.	25.69	36.98	21.33	37.67	25.27	31.61			
D.I.	N.S.	N.S.	N.S.	N.S.	N.S.	6.68*	11.24	6.88*	16.04	7.13*	12.25	N.S.		
Hot	68.46	74.53	53.75	21.54	42.69	15.42	12.08	18.22	11.90	20.14	10.06	71.76	45.(	
Rh	N.S.	N.S.	N.S.	N.S.	N.S.	26.89	37.55	24.05	41.01	26.90	33.91	N.S.	N.S	
Om 1	18.69	20.31	8.27*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	22.65	N.S	
Om 2	11.72	13.60	N.S.	N.S.	N.S.	15.20	20.97	16.39	30.13	21.37	25.16	N.S.	N.S	
Sw	11.81	7.51*	N.S.	N.S.	N.S.	N.S.	N.S.	7.75*	14.15	8.26	10.00	22.21	N.S	
Ve	16.37	10.8*	N.S.	N.S.	N.S.	16.31	22.22	18.42	30.76	23.29	21.58	12.01*	N.S	
Si	12.23	13.97	N.S.	N.S.	N.S.	5.85*	10.66	7.26*	18.08	12.40	12.45	N.S.	N.S	
I.E.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	8.42*	N.S.	5.98*	N.S.	N.S	
St.R.	N.S.	N.S.	N.S.	N.S.	N.S.	10.68	17.03	8.79*	17.32	8.62*	12.35	N.S.	N.S	
	Pek	So	Nea	Sk.5	Sac 1	U.P.	Me	No	Zu	Tas	Es	Pet	D.I	

Fig. 13

Analysis 3 (occipital bone). Graphical representation of generalised distances (D^2) for fossil and recent material. Hotu and Pekin as reference axes.

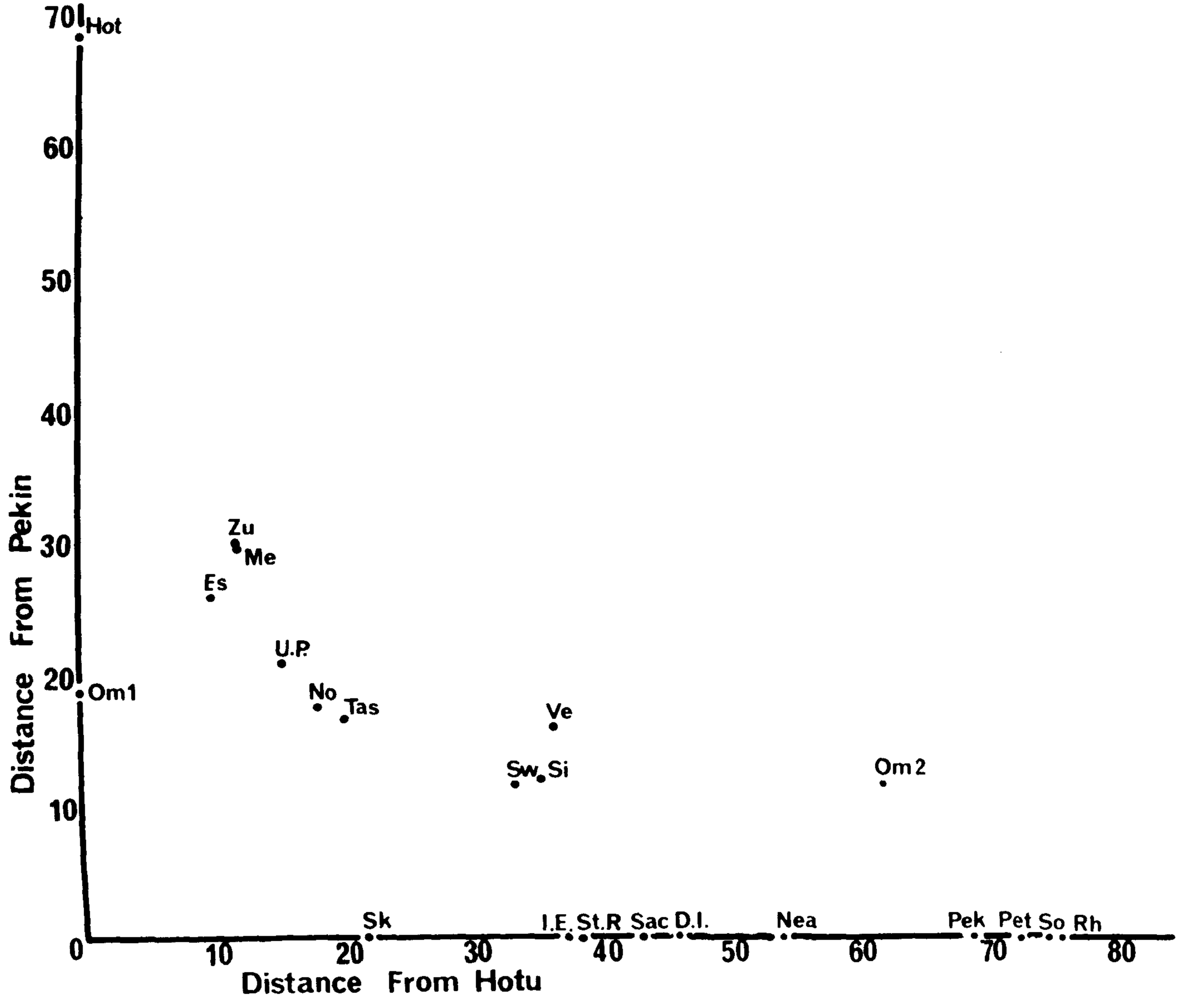

70
Hot
60
50
40
30
20
10
0
Distance From Pekin
Zu
Me
Es
U.P.
No
Tas
Om1
Ve
Sw
Si
Om2
Sk
I.E.
St.R
Sac
D.I.
Nea
Pek
Pet
So
Rh
10
20
30
40
50
60
70
80
Distance From Hotu

Fig. 14

Analysis 3 (occipital bone). Dendrogram from generalised distances (D^2) matrix.

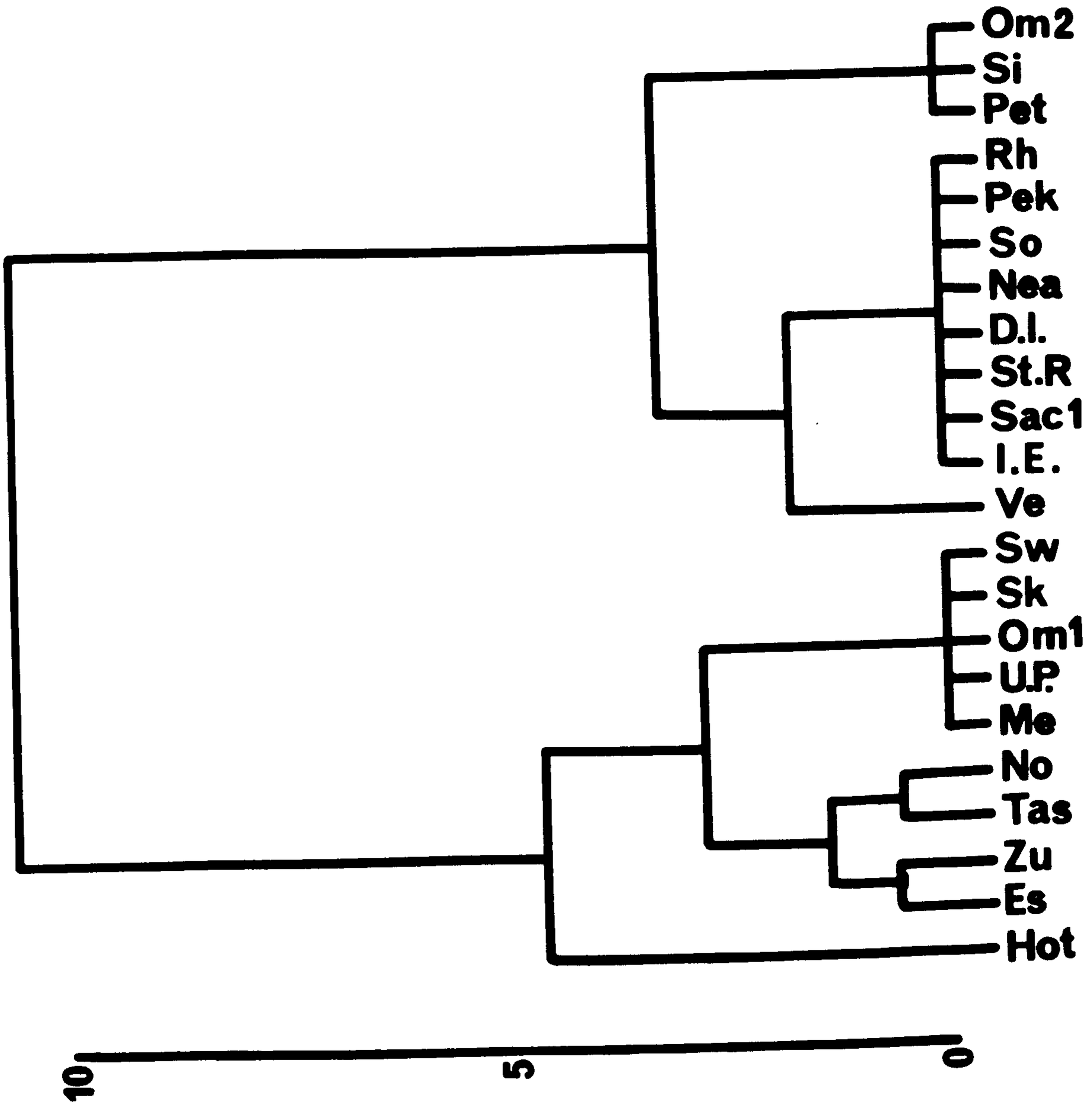
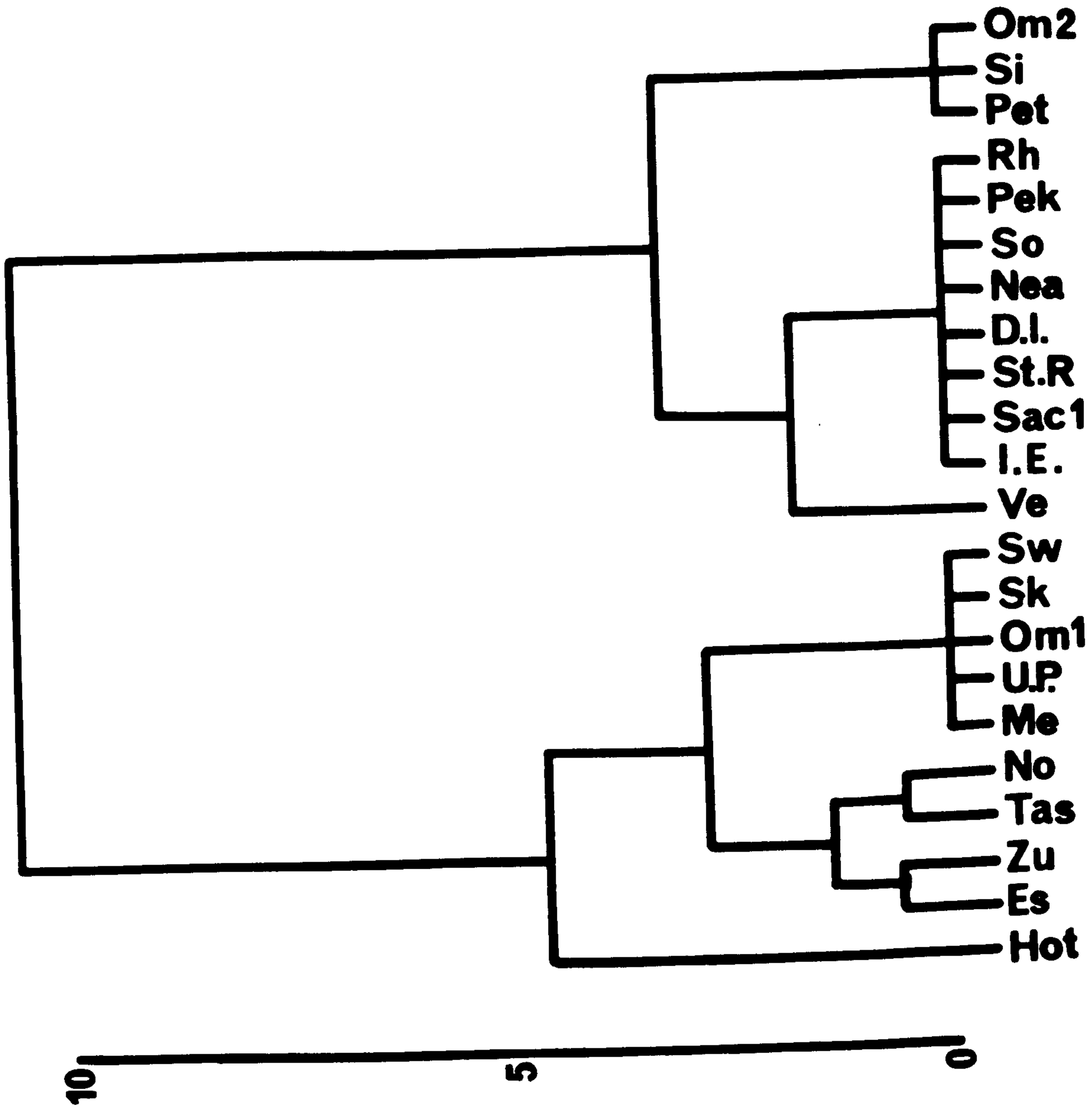

Om2
Si
Pet
Rh
Pek
So
Nea
D.I.
St.R
Sac1
I.E.
Ve
Sw
Sk
Om1
U.P.
Me
No
Tas
Zu
Es
Hot
10
5
0

Fig. 14

Analysis 3 (occipital bone). Dendrogram from generalised distances (D^2) matrix.


Om2
Si
Pet
Rh
Pek
So
Nea
D.I.
St.R
Sac1
I.E.
Ve
Sw
Sk
Om1
U.P.
Me
No
Tas
Zu
Es
Hot
10
5
0

Analysis 3 Occipital Contributions of variables to D^2 analysis in order of importance

Distance from Pekin

Solo*	-ASB	-OCF	+OCS	+OCC
Neanderthal*	-OCC	+OCS	-ASB	-OCF
Skhūl*	-OCF	-OCC	+OCS	+ASB
Saccopastore*	-OCC	+OCS		
Upper Palaeolithic	-OCC	+OCS	+ASB	-OCF
Mesolithic	-OCC	+OCS	+ASB	-OCF
Norse	-OCC	+ASB	+OCS	-OCF
Zulu	-OCC	+ASB	+OCS	-OCF
Tasmanian	+ASB	-OCC	+OCS	-OCF
Eskimo	-OCC	+ASB	+OCS	+OCF
Petralona*	-OCS	-OCC		
Djebel Irhoud*	+OCS	-OCC	-ASB	-OCF
Hotu	-OCF	-OCC	+ASB	+OCS
Rhodesian*	-OCS	-ASB	-OCF	
Omo 1	-OCC	-OCF	+OCS	+ASB
Omo 2	-OCC	-ASB		
Swanscombe	+OCS	-OCC	-OCF	-ASB
Vértesszőllős	-OCF	-OCC	-ASB	
Singa	-OCC	-OCF	-ASB	
Iwo Eleru*	-OCC	+OCS	+ASB	
Steinheim reconstruction*	-OCF	+OCS	+ASB	

Analysis 3 Occipital (contd.)

Distance from Neanderthal

Pekin*	+OCC	-OCS	+ASB	+OCF
Solo*	+OCC	-ASB	-OCS	
Skhūl*	-OCF	+ASB	-OCC	+OCS
Saccopastore*	+ASB	-OCC	+OCF	+OCS
Upper Palaeolithic	+ASB	-OCC	+OCS	-OCF
Mesolithic	+ASB	-OCC	+OCS	-OCF
Norse	+ASB	-OCC	+OCS	-OCF
Zulu	+ASB	-OCC	+OCS	-OCF
Tasmanian	+ASB	+OCS	-OCC	-OCF
Eskimo	+ASB	-OCC	-OCF	+OCS
Petralona*	-OCS	+ASB		
Djebel Irhoud*	+OCS	+ASB		
Hotu	-OCF	+ASB	-OCC	+OCS
Rhodesian*	-OCS	+OCC	-ASB	-OCF
Omo 1	-OCF	+ASB	-OCC	+OCS
Omo 2*	-OCC	-OCS	-ASB	+OCF
Swanscombe*	+OCS	-OCF	-OCC	
Vértesszöllös*	-OCF	-OCS	-OCC	-ASB
Singa*	-OCC	-OCS	-OCF	
Iwo Eleru*	+ASB	-OCC	+OCS	+OCF
Steinheim reconstruction*	-OCF	+ASB	+OCC	

Analysis 3 Occipital (contd.)

Distance from Upper Palaeolithic

Pekin +OCC −OCS −ASB +OCF

Solo +OCC −ASB −OCS +OCF

Neanderthal −ASB +OCC −OCS +OCF

Skhūl* +OCC −ASB −OCS −OCF

Saccopastore* −ASB +OCF +OCC −OCS

Mesolithic* +OCS −OCC +ASB −OCF

Norse +ASB −OCS +OCC +OCF

Zulu +ASB +OCS

Tasmanian +OCC +ASB +OCF

Eskimo +ASB −OCF +OCC +OCS

Petralona −OCS +OCC −ASB +OCF

Djebel Irhoud +OCC −ASB +OCF −OCS

Hotu −OCF +ASB −OCC +OCS

Rhodesian −OCS +OCC −ASB +OCF

Omo 1* −OCF −ASB −OCS

Omo 2 −ASB −OCS +OCF −OCC

Swanscombe* −ASB +OCC +OCS

Vértesszöllös −ASB −OCF −OCS

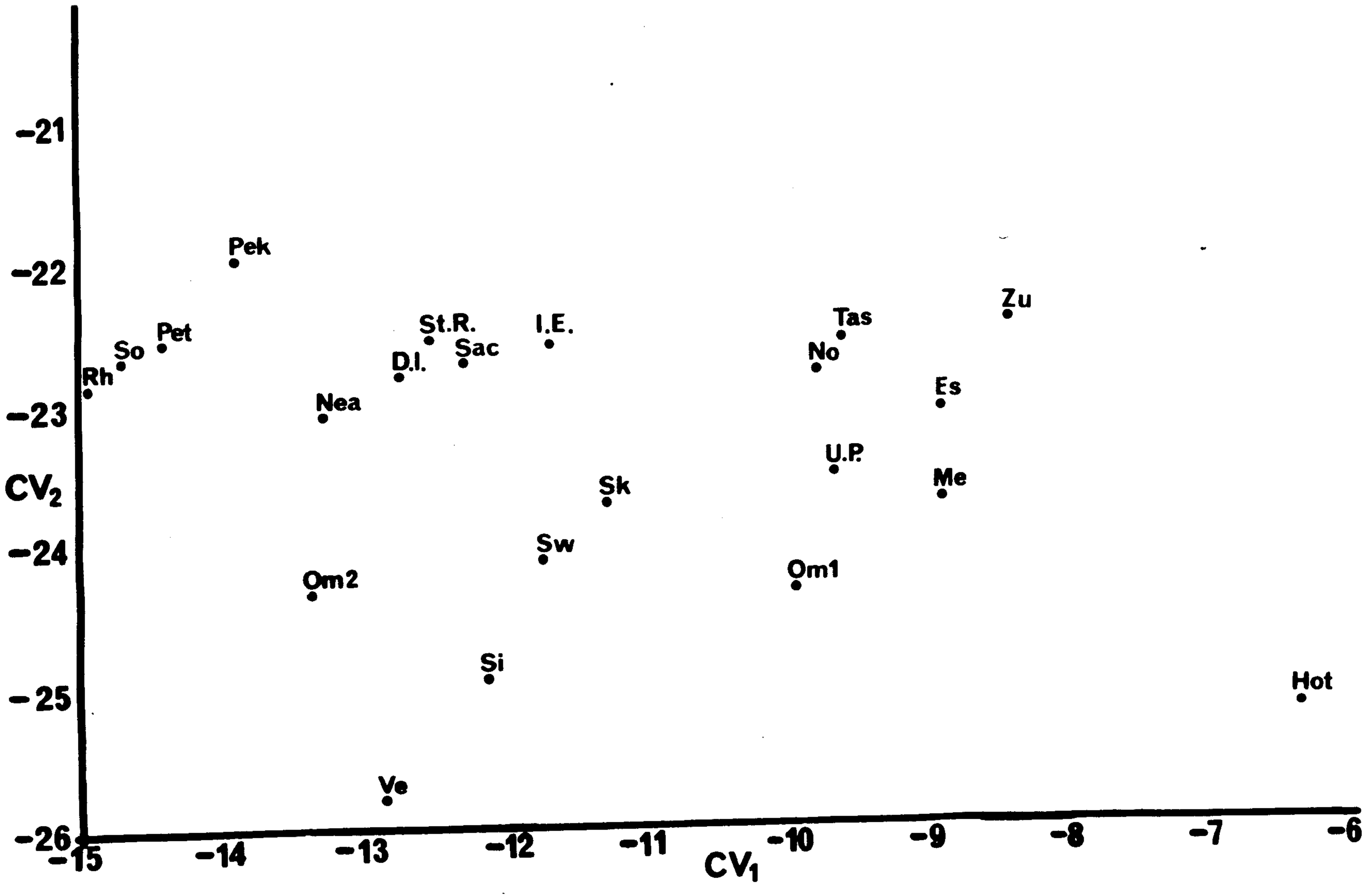
Singa −ASB −OCS

Iwo Eleru* +OCC +OCF −ASB −OCS

Steinheim reconstruction +OCC −OCS −ASB −OCF

Fig. 15

Analysis 3 (occipital bone). Plot of canonical variates 1 and 2 for fossil and recent material.


-21
-22
-23
-24
-25
-26
CV2
-15
-14
-13
-12
-11
-10
-9
-8
-7
-6
CV1
Pek
Pet
So
Rh
Nea
St.R.
I.E.
D.I.
Sac
Tas
Zu
No
Es
U.P.
Sk
Me
Sw
Om2
Om1
Si
Hot
Ve

Analysis 4 Frontal and parietals (Figs 16 - 18)

Variables used (10)

XCB, STB, ASB, SOS, FRC, FRS, FRF, PAC, PAS, PAF

Sample

Pekin E, L.1, L.2, L.3 (4)

Solo 1, 5, 6, 11 (4)

Neanderthal Sp. 1, 2, M.C., L.Ch., Qu, Gi, Mo, Fe, (8)

Middle-east Neanderthals Am, Tab (2)

Skhūl Sk. 5 (1)

Saccopastore Sac 1 (1)

Upper Palaeolithic En, Pr. 3, 4, Br 1, 2, 3, Ob 1, 2, D.V.3, Lau 1, Or, S.T.3, A.C. 1, 4, 6, Gri, Ch, Cr 1, 2, 3, Ko, L.B.2., L.R., C.C., Lan, G.C., F.J. (27)

Mesolithic Hoh 1, 2, Kau, Of 2, 11, 25, Af 9, 10, 29, 32, Te 1, 11 Taf 11, 17, Gra (15)

Modern populations No (110), Zu (102), Tas (86) Es (108)

Individual cases Co, Pet, D.I., Hot, Rh, Om 1, 2, Si, Sald, I.E., St.R.

TABLE 4 Matrix of generalised distances (D^2)

Analysis 4 - frontal & parietal bone

7.07										
02.7	N.S.									
5.95	62.73	71.31								
2.7	N.S.	N.S.	57.64							
5.92	40.48	55.21	N.S.	24.24*						
4.10	56.62	36.56	29.33	24.96*	18.91*					
06.6	16.94*	37.29	66.11	N.S.	26.38	53.0				
3.92	18.14*	30.44	21.1*	N.S.	N.S.	22.62*	N.S.			
5.40	51.62	42.63	N.S.	49.32	N.S.	N.S.	51.15	N.S.		
7.50	22.87*	N.S.	51.37	23.0*	66.57	51.05	42.85	23.61*	59.94	
	Pet	D.I.	Hot	Rh	Om 1	Om 2	Si	Sald	I.E.	St.R.

Pek												
So	7.27											
Nea	7.43	8.98										
M.E.N.	15.44	8.78*	N.S.									
Sk.5	36.03	23.42	22.96	13.99*								
Sac 1	14.93*	N.S.	9.82*	N.S.	N.S.							
U.P.	59.42	39.05	46.67	45.12	N.S.	35.98						
Me	63.71	39.82	48.46	46.16	N.S.	31.11	1.23*					
No	57.91	37.98	48.41	51.71	12.84*	35.92	6.40	4.35				
Zu	73.48	55.78	65.58	68.89	21.46	55.17	6.23	8.32	4.35			
Tas	50.33	42.07	45.70	51.95	N.S.	40.04	6.31	8.79	5.94	7.09		
Es	63.96	48.56	65.09	66.46	9.77*	46.18	7.68	7.41	7.84	8.89	5.77	
Co	81.0	68.49	81.97	86,1	51.33	75.21	78.37	74.46	92.21	107.20	89.02	74.
Pet	21.22	26.39	N.S.	N.S.	20.98*	N.S.	65.51	59.75	72.13	97.00	67.88	80.
D.I.	21.87	27.68	15.69	14.19*	23.97*	N.S.	56.40	60.46	74.56	86.89	59.76	76.
Hot	63.73	39.66	50.5	53.45	N.S.	29.68	N.S.	N.S.	N.S.	N.S.	N.S.	N.S
Rh	N.S.	N.S.	N.S.	N.S.	26.03*	16.81*	55.15	60.38	71.55	86.49	66.26	76.
Om 1	39.51	20.03	23.85	39.75	17.77*	32.71	14.12	13.12*	15.55	24.19	23.82	27.
Om 2	40.29	N.S.	35.67	33.89	34.02	N.S.	31.30	36.46	39.81	50.09	48.69	49.
Si	N.S.	12.66*	N.S.	N.S.	40.14	23.41*	64.22	64.19	58.73	77.28	63.27	78.
Sald	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	25.43	27.95	26.36	39.60	24.43	38.
I.E.	35.15	13.63*	29.02	43.76	23.94*	16.67*	18.83	17.37	11.89*	25.25	15.68	23.
St.R.	27.57	32.78	20.75	N.S.	N.S.	N.S.	38.93	44.98	54.46	61.10	41.02	56.
	Pek	So	Nea	M.E.N.	Sk.5	Sac 1	U.P.	Me	No	Zu	Tas	Es

Fig. 16

Analysis 4 (frontal and parietals). Graphical representation of generalised distances (D^2) for fossil and recent material. Zulu and Neanderthal as reference axes.

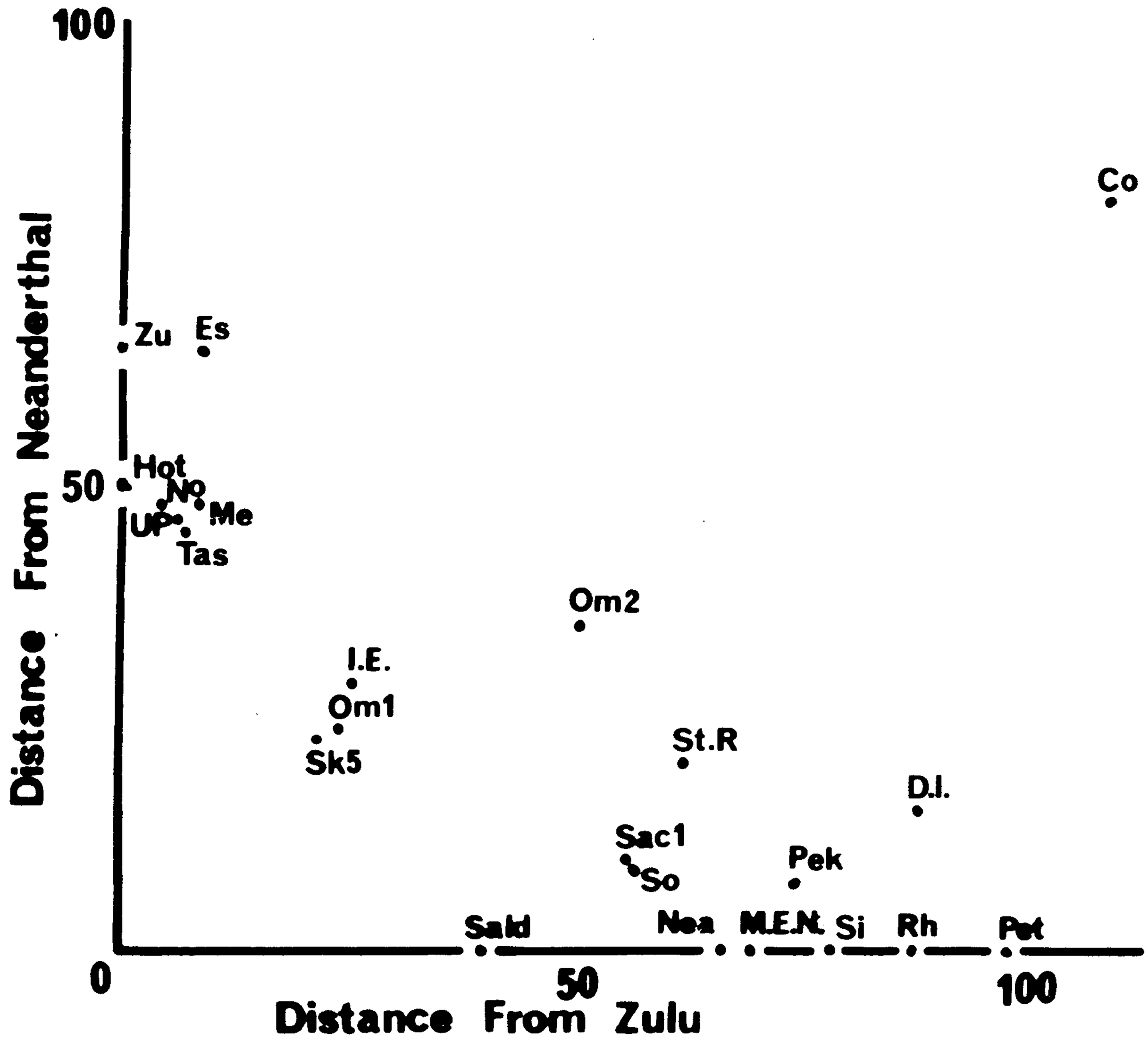
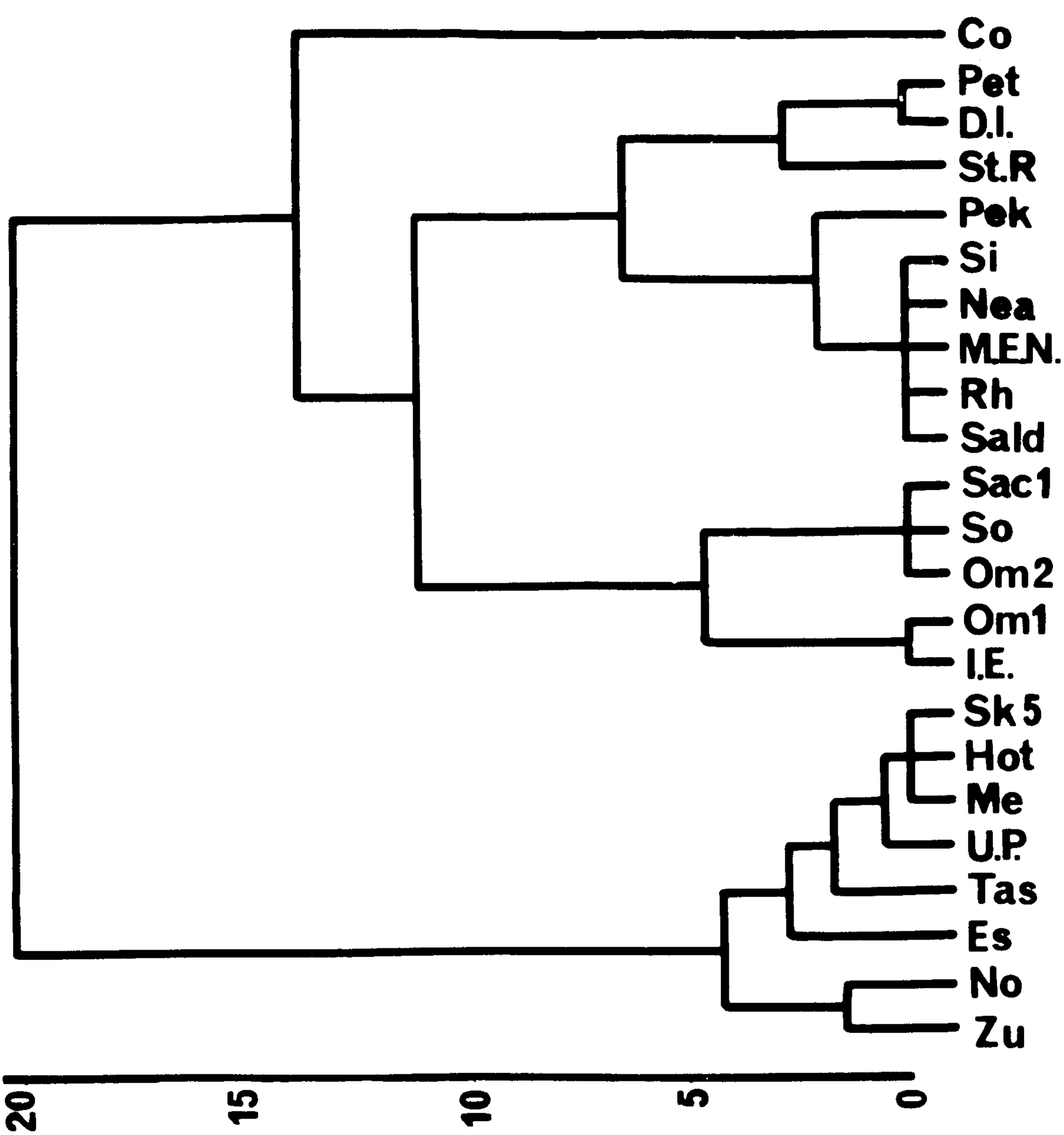

100
50
0
Distance From Neanderthal
Distance From Zulu
Zu
Es
Hot
No
Me
Up
Tas
Om2
I.E.
Om1
Sk5
St.R
D.I.
Sac1
So
Pek
Said
Nea
M.E.N.
Si
Rh
Pet
Co

Fig. 17

Analysis 4 (frontal and parietals). Dendrogram from generalised distances (D^2) matrix.


Co
Pet
D.I.
St.R
Pek
Si
Nea
M.E.N.
Rh
Sald
Sac1
So
Om2
Om1
I.E.
Sk 5
Hot
Me
U.P.
Tas
Es
No
Zu
20
15
10
5
0

Analysis 4 Frontal and parietals Contributions of variables to D^2 analysis in order of importance

Distance from Pekin

Solo	-STB	+SOS	-ASB	-PAC	-FRC	-PAF
Neanderthal	-STB	-PAS	-XCB	-PAC	-PAF	-SOS
Middle-east Neanderthals	-STB	-PAS	-ASB	+FRC	-PAC	-FRF
Skhūl	-PAS	-PAC	-FRS	+SOS	-FRF	+FRC
Saccopastore	+FRC	+SOS	-PAC	-PAF	-STB	-FRF
Upper Palaeolithic	-PAC	-PAS	+SOS	-FRS	-STB	-PAF
Mesolithic	+SOS	-PAS	-PAC	-STB	-FRS	-PAF
Norse	+SOS	-PAS	-STB	-PAF	+ASB	+FRF
Zulu	+SOS	-PAS	+ASB	+FRF	-PAC	-STB
Tasmanian	-PAS	+SOS	-PAC	+ASB	+FRF	-FRS
Eskimo	+SOS	-PAS	-PAC	-FRS	+ASB	+XCB
Cohuna	-FRF	-PAS	+XCB	-FRC	+SOS	+ASB
Petralona	-FRF	-XCB	-PAC	-PAF	-PAS	-SOS
Djebel Irhoud	+PAC	+FRC	-XCB	-FRS	-FRF	-SOS
Hotu	+SOS	-PAS	-PAF	+ASB	-PAC	-STB
Rhodesian*	-FRF	-PAC	-SOS	-STB	-PAF	-ASB
Omo 1	-FRC	-PAS	-PAF	-STB	+SOS	-PAC
Omo 2	-PAC	+SOS	-STB	-PAF	-ASB	-FRC
Singa*	-STB	-FRS	-XCB	-PAS	-SOS	-ASB
Saldanha*	-PAS	-STB	-FRC	+FRS	+ASB	-PAF
Iwo Eleru	+SOS	-PAC	-STB	+FRF	-XCB	+FRS
Steinheim reconstruction	+FRC	-PAC	+XCB	-PAS	-FRS	-STB

Analysis 4 Frontal and parietals (contd.)

Distance from Neanderthal

Pekin	+STB	+PAS	+XCB	+PAC	+PAF	+SOS
Solo	+SOS	-ASB	+XCB	-FRC	+PAS	+FRS
Middle-east Neanderthals*	-ASB	+FRC	-FRS	+XCB	-STB	+PAF
Skhūl	+SOS	-FRS	-PAC	-PAS	+XCB	+STB
Saccopastore	+SOS	+FRC	+PAS	-PAF	-FRF	+FRS
Upper Palaeolithic	+SOS	-PAC	+XCB	-FRS	-PAS	+FRF
Mesolithic	+SOS	-PAC	-PAS	-FRS	+XCB	+ASB
Norse	+SOS	-PAS	+XCB	+FRF	+ASB	-FRS
Zulu	+SOS	+XCB	+FRF	+ASB	-FRS	-PAS
Tasmanian	+SOS	+FRF	-PAS	+ASB	+XCB	+STB
Eskimo	+SOS	+XCB	-FRS	+STB	-PAS	+ASB
Cohuna	-FRF	+XCB	+STB	-FRC	+SOS	-PAS
Petralona*	-FRF	-XCB	+STB	+FRC	-PAF	-PAC
Djebel Irhoud	-PAC	+PAS	+FRC	-FRS	+STB	+PAF
Hotu	+SOS	+XCB	+ASB	-PAF	-PAS	-PAC
Rhodesian*	-FRF	+XCB	-PAC	-SOS	-ASB	-FRC
Omo 1	-FRC	+SOS	-PAF	-PAS	+ASB	-PAC
Omo 2	+SOS	-PAC	+XCB	-PAF	-ASB	-FRC
Singa*	+PAC	-FRS	-FRC	-ASB	-XCB	
Saldanha*	+XCB	-PAS	-FRC	+FRS	+SOS	+ASB
Iwo Eleru	+SOS	-PAC	+FRF	+FRS	-FRC	+ASB
Steinheim reconstruction	+FRC	+XCB	-FRS	-PAC	+STB	+PAF
Steinheim reconstruction	+FRC	+XCB	-FRS	-PAC	+STB	+PAF

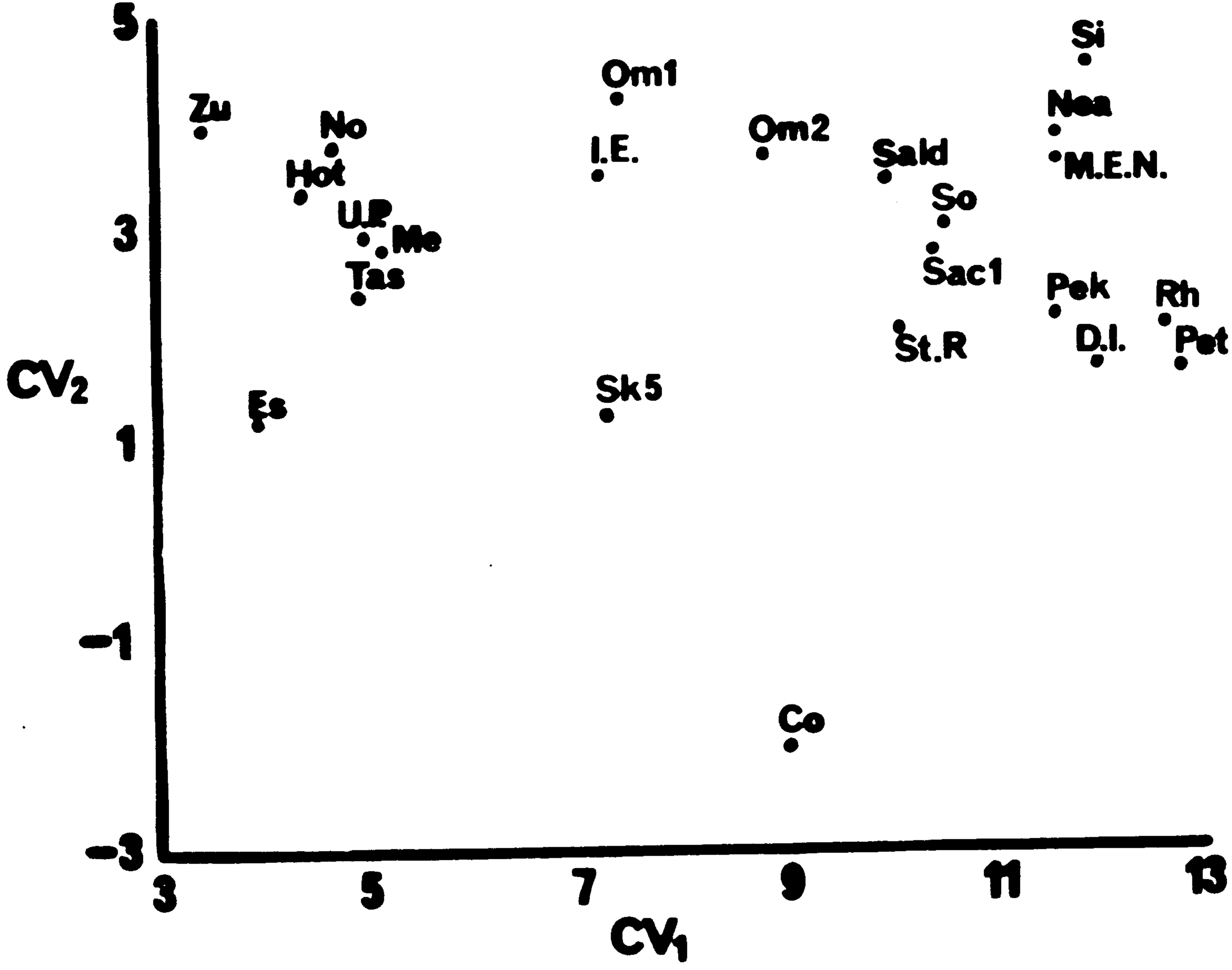
Analysis 4 Frontal and parietals (contd.)

Distance from Upper Palaeolithic

Pekin	+PAC	+PAS	-SOS	+FRS	+STB	+PAF
Solo	+PAS	-ASB	+PAC	-SOS	-FRF	-XCB
Neanderthal	-SOS	+PAC	-XCB	+FRS	+PAS	-FRF
Middle-east Neanderthals	-SOS	-ASB	+PAC	-FRF	+FRC	+PAS
Skhūl*	-FRF	+FRC	-SOS	-ASB	-XCB	+STB
Saccopastore	+PAS	+FRC	-FRF	+FRS	-XCB	+PAC
Mesolithic	-FRF	+SOS	-XCB	+PAC	-PAS	-STB
Norse	+PAC	+SOS	+FRS	+FRF	-XCB	+ASB
Zulu	+FRF	+PAC	+ASB	+SOS	+XCB	
Tasmanian	+STB	+FRF	+PAC	+PAF	+ASB	+FRS
Eskimo	+STB	+SOS	+PAC	+PAF	+ASB	
Cohuna	-FRF	+FRS	+STB	-SOS	-FRC	+PAF
Petralona	-FRF	-XCB	-SOS	+PAS	+PAC	+FRC
Djebel Irhoud	-PAS	-SOS	-XCB	+FRC	+PAF	+PAC
Hotu*	+ASB	-FRF	+PAC	-PAF	+SOS	+FRS
Rhodesian	-SOS	-FRF	+PAS	-ASB	+FRS	+PAC
Omo 1	-FRC	-XCB	-SOS	-PAF	+FRS	-FRF
Omo 2	+PAS	+FRS	-ASB	-PAF	-FRC	-STB
Singa	+PAC	-SOS	-XCB	+PAS	-ASB	-FRF
Saldanha	-SOS	+FRS	+PAC	-FRF	+PAF	-FRC
Iwo Eleru	+FRS	-XCB	+PAS	+PAF	+SOS	-FRC
Steinheim reconstruction	+FRC	-SOS	+PAS	+PAF	-ASB	+STB

Fig. 18

Analysis 4 (frontal and parietals). Plot of canonical variates 1 and 2 for fossil and recent material


5
3
1
−1
−3
CV2
Zu
No
Hot
U.P.
Me
Tas
Es
Om1
I.E.
Sk5
Om2
Sald
So
Sac1
St.R
Si
Nea
M.E.N.
Pek
Rh
D.I.
Pet
Co
3
5
7
9
11
13
CV1

Analysis 5 Parietals and occipital (Figs 19-21)

Variables used (8)

XCB, ASB, PAC, PAS, PAF, OCC, OCS, OCF

Sample

Pekin E, L.1, L.2, L.3. (4)

Solo 1, 5, 6, 11 (4)

Neanderthal L.Ch., Gi, Fe (3)

Skhūl Sk.5 (1)

Saccopastore Sac. 1 (1)

Upper Palaeolithic En, Pr. 3, 4, Ob 1, 2, Stt, Br. 3, D.V.3, Lau 1, Or, S.T.3, A.C.1, 4, 6, Gri, Ch, Cr. 1, Ko, C.C., Lan, G.C., F.J. (22)

Mesolithic Hoh 1, 2, Kau, Of 11, 25, Af 9, 29, Te 1, 11, Taf 11, 17 Gra (12)

Modern populations No (110), Zu (102), Tas (86) Es (108)

Individual cases Pet, D.I., Hot, Rh, Om 1, 2, Sw, Si, I.E., St.R.

TABLE 5 Matrix of generalised distances (D^2)

Analysis 5 - parietal and occipital bone

.69*					
S.	N.S.				
.00*	29.73	N.S.			
S.	N.S.	N.S.	N.S.		
.66*	21.83*	N.S.	34.41	N.S.	
1	Om 2	Sw	Si	I.E.	St.R.

Pek															
So	N.S.														
Nea	6.16*	N.S.													
Sk 5	35.01	24.95	16.32												
Sac 1	N.S.	N.S.	N.S.	N.S.											
U.P.	58.65	50.82	37.06	N.S.	23.01										
Me	62.89	55.41	37.19	N.S.	24.20	N.S.									
No	41.28	40.52	25.55	N.S.	14.28	5.08	4.94								
Zu	57.15	56.06	41.16	N.S.	24.15	3.18	2.69	4.10							
Tas	43.90	42.94	29.90	N.S.	18.30	3.86	4.20	2.49	2.56						
Es	54.70	52.57	40.88	N.S.	25.51	2.72	3.42	4.57	1.61	2.26					
Pet	13.23*	14.49*	N.S.	23.7*	N.S.	47.18	51.68	28.95	52.55	39.24	52.43				
D.I.	18.12	11.43*	N.S.	23.53*	N.S.	38.90	40.61	41.00	44.77	35.51	44.85	29.26			
Hot	103.4	95.4	76.77	16.58*	58.55	11.48*	9.18*	19.55	9.13*	19.97	8.82*	90.5	76.97		
Rh	N.S.	N.S.	N.S.	N.S.	N.S.	35.21	43.98	29.33	44.61	32.98	40.98	N.S.	N.S.	79.37	
Om 1	42.23	31.76	13.05*	N.S.	N.S.	N.S.	N.S.	N.S.	8.66*	9.19*	11.57*	21.95*	17.26*	N.S.	21.1
Om 2	31.09	22.08	20.39	25.01	N.S.	29.84	37.00	36.31	42.27	39.66	41.60	28.98	N.S.	70.74	N.S.
Sw	13.14*	N.S.	N.S.	N.S.	N.S.	20.56	20.05	19.98	24.65	20.21	23.49	28.61	N.S.	46.11	N.S.
Si	13.41*	17.81	N.S.	31.6	N.S.	49.21	47.04	29.33	50.05	42.60	48.49	N.S.	32.55	76.19	18.4
I.E.	11.97*	N.S.	N.S.	N.S.	N.S.	10.08*	10.82	N.S.	13.68	N.S.	15.17	N.S.	N.S.	43.32	N.S.
St.R.	14.32*	N.S.	15.77*	N.S.	N.S.	15.08	21.87	13.96	18.37	10.45*	11.97*	26.15	17.15*	38.86	N.S.
	Pek	So	Nea	Sk.5	Sac 1	U.P.	Me	No	Zu	Tas	Es	Pet	D.I.	Hot	Rh

Fig. 19

Analysis 5 (parietals and occipital).

Graphical representation of generalised distances (D^2) for fossil and recent material. Eskimo and Pekin as reference axes.

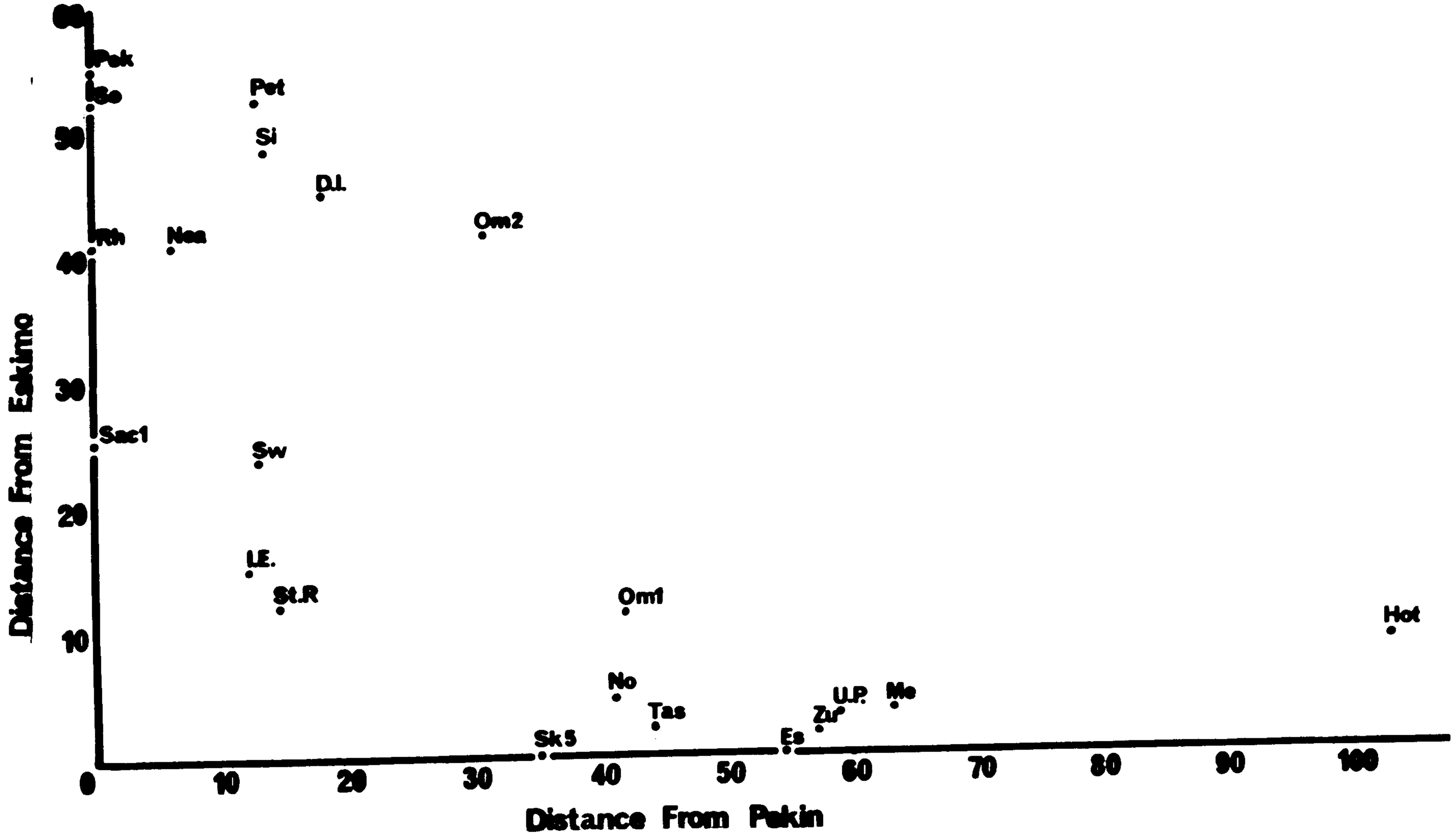
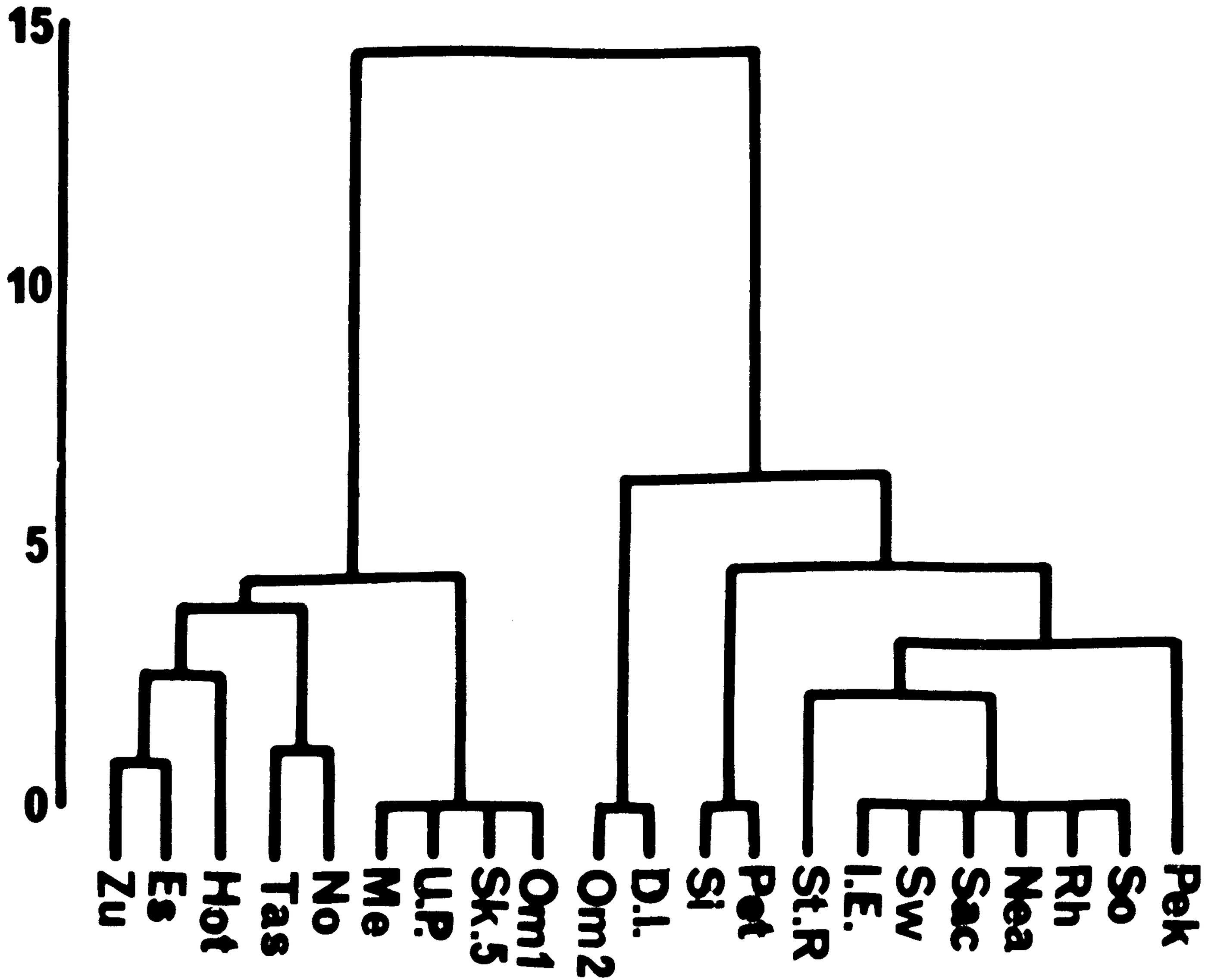

Pek
Ige
Pet
Si
p.l.
Om2
Rth
Nan
Eskimo
Sac1
Sw
I.E.
St.R
Om1
Hot
No
Tas
U.P.
Me
Zur
Sk5
Es
0
10
20
30
40
50
60
70
80
90
100
Distance From Pekin

Fig. 20

Analysis 5 (parietals and occipital). Dendrogram from generalised distances (D^2) matrix.


15
10
5
0
Zu
Es
Hot
Tas
No
Me
U.P.
Sk.5
Om1
Om2
D.I.
St
Pot
St.R
I.E.
Sw
Sac
Nea
Rh
So
Pek

Analysis 5 Parietals and occipital Contributions of variables to D^2 analysis in order of importance

Distance from Pekin

Solo* -ASB -PAC -OCF -PAF +OCS -PAS

Neanderthal -XCB -PAC -PAS -OCC +OCS -PAF

Skhūl -PAS -PAC -OCF -OCC +OCS +ASB

Saccopastore* -OCC -PAF -PAC +OCS -PAS

Upper Palaeolithic -PAS -PAC -OCC +OCS +ASB -OCF

Mesolithic -PAS -OCC -PAC +OCS +ASB -OCF

Norse -PAS -OCC +ASB -PAC +OCS -OCF

Zulu -PAS +ASB -OCC -PAC +OCS +XCB

Tasmanian -PAS -PAC +ASB -OCC +OCS -OCF

Eskimo -PAS -OCC -PAC +ASB -OCF +OCS

Petralona -XCB -PAS -OCS -PAF -OCC

Djebel Irhoud -PAS +OCS -OCC -XCB -OCF

Hotu -OCF -OCC -PAS +ASB -PAC +OCS

Rhodesian* -PAC -PAF -OCS -PAS -OCF -ASB

Omo 1 -XCB -PAS -OCC -ASB -PAC +PAF

Omo 2 -PAC -OCC -PAF -ASB

Swanscombe +OCS -PAC -OCC -OCF -PAF -ASB

Singa -OCC -XCB -PAF -PAS -OCF

Iwo Eleru -PAC -OCC -PAS +OCS -XCB +ASB

Steinheim reconstruction -PAC -OCF -PAS +XCB +OCS +ASB

Analysis 5 Parietals and occipital (contd.)

Distance from Neanderthal

Pekin	+XCB	+PAC	+PAS	+OCC	-OCS	+PAF
Solo*	+XCB	+OCC	-ASB	+PAS	-OCS	
Skhūl	-PAS	+XCB	-PAC	-OCF	+ASB	-OCC
Saccopastore*	+XCB	+PAS	-OCC	-PAF	+OCF	+OCS
Upper Palaeolithic	+XCB	-PAS	-PAC	-OCC	+ASB	-OC
Mesolithic	-PAS	-OCC	+XCB	+ASB	-PAC	+OCS
Norse	-PAS	+ASB	+XCB	-OCC	-OCF	+OCS
Zulu	+ASB	+XCB	-PAS	-OCC	+OCS	-PAC
Tasmanian	+ASB	+XCB	-PAS	-PAC	-OCC	+OCS
Eskimo	+XCB	+ASB	-PAS	-OCC	-OCF	-PAC
Petralona*	-OCS	-PAS	-PAF	+ASB	-XCB	
Djebel Irhoud*	-PAC	+PAS	+OCS	+PAF	+XCB	+ASB
Hotu	-OCF	+ASB	-OCC	+XCB	-PAS	-PAC
Rhodesian*	-OCS	+XCB	-PAC	-PAF	-ASB	+OCC
Omo 1	-OCF	+ASB	-PAC	-OCC	-PAF	-PAS
Omo 2	-PAC	+XCB	-OCC	-PAF	-ASB	+PAS
Swanscombe*	+OCS	+XCB	-OCF	-OCC	-PAC	+PAS
Singa*	+PAC	-OCC	-OCS	-XCB	-ASB	
Iwo Eleru*	-PAC	+ASB	+XCB	-OCC	+OCS	+OCF
Steinheim reconstruction	+XCB	-OCF	+PAF	-PAS	+OCC	-PAC

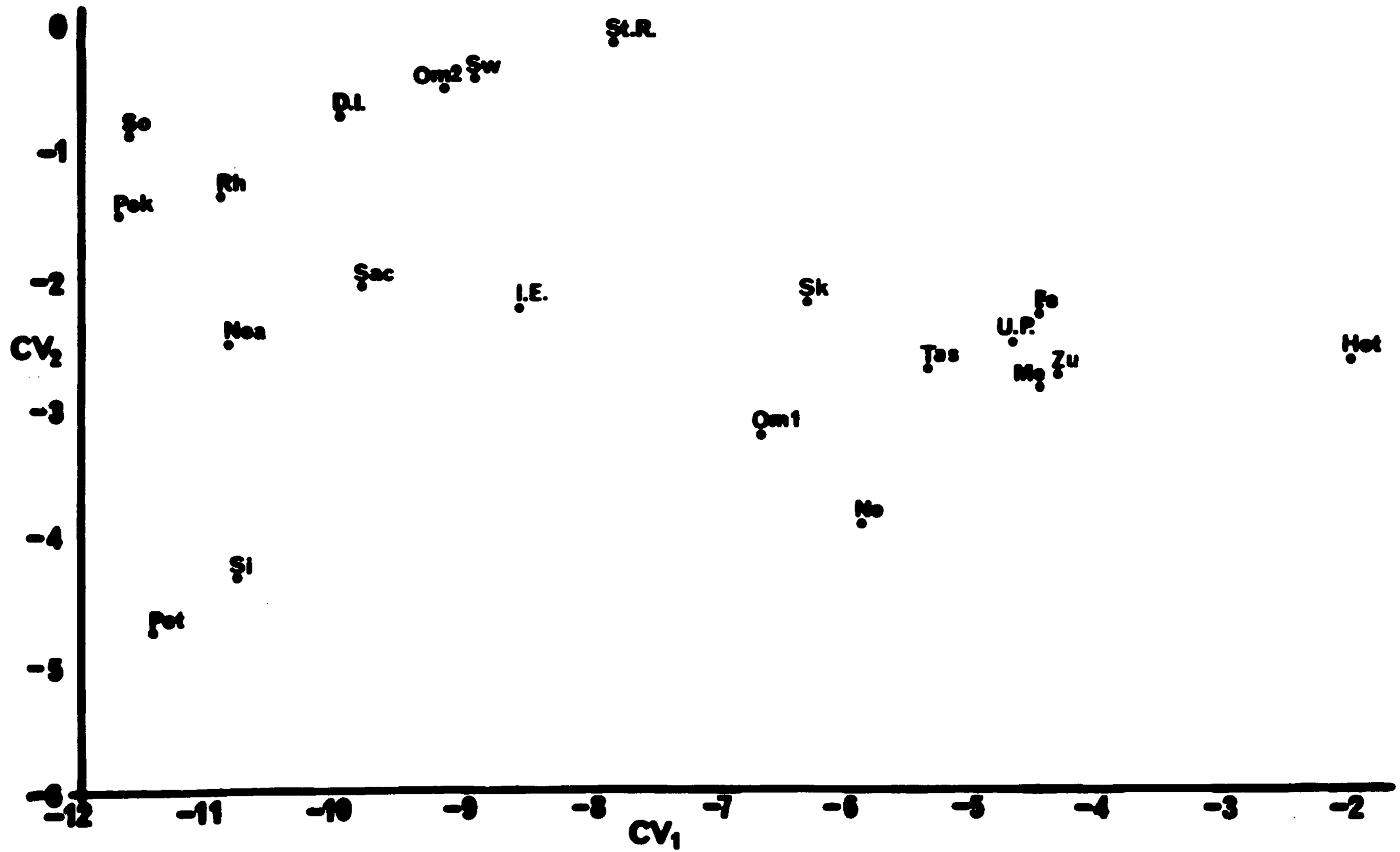
Analysis 5 Parietals and occipital (contd.)

Distance from Upper Palaeolithic

Pekin	+PAS	+PAC	+OCC	-OCS	-ASB	+OCF
Solo	+OCC	+PAS	-ASB	+PAC	-XCB	-OCS
Neanderthal	-XCB	+PAS	+PAC	+OCC	-ASB	+OCF
Skhūl*	+OCC	-ASB	+PAF	-XCB	-OCS	-OCF
Saccopastore	+PAS	+PAC	-ASB	+OCC	+OCF	-XCB
Mesolithic*	+OCS	-XCB	+PAC	-OCC	+ASB	-PAS
Norse	+PAC	-XCB	-OCS	+OCC	+ASB	+OCF
Zulu	+ASB	+PAC	+OCS	+PAS	+OCC	
Tasmanian	+PAC	+PAF	+OCC	+ASB	+OCF	
Eskimo	+PAC	+PAF	+ASB	+XCB	-OCF	+OCC
Petralona	-OCS	-XCB	+PAC	+OCC	+PAS	+OCF
Djebel Irhoud	+PAS	-XCB	+OCC	-ASB	+PAF	+OCF
Hotu	-OCF	+ASB	-OCC	+OCS	-PAF	+XCB
Rhodesian	-OCS	+OCC	+PAS	-ASB	-XCB	+PAC
Omo 1*	-XCB	+PAS	-PAF	-OCF	-PAC	
Omo 2	+PAS	-ASB	-OCS	+OCF	-PAF	-PAC
Swanscombe	+PAS	-ASB	+OCC	-XCB	+PAC	+OCS
Singa	+PAC	-XCB	+PAS	-ASB	-OCS	
Iwo Eleru	+PAS	-XCB	+OCC	+OCF	-ASB	-OCS
Steinheim reconstruction	+OCC	+PAS	-ASB	-OCS	+PAF	+PAC

Fig. 21

Analysis 5 (parietals and occipital). Plot of canonical variates 1 and 2 for fossil and recent material.


0
−1
−2
−3
−4
−5
−6
CV2
−12
−11
−10
−9
−8
−7
−6
−5
−4
−3
−2
CV1
St.R.
Om2
Sw
D.L
Şo
Rh
Pek
Şac
I.E.
Şk
Fe
U.P.
Tas
Mg
Zu
Het
Om1
Ne
Si
Pet
Nea

Analysis 6 Frontal, parietals and occipital (Figs 22-24)

Variables used (13)

XCB, STB, ASB, SOS, FRC, FRS, FRF, PAC, PAS, PAF,

OCC, OCS, OCF

Sample

Pekin E, L1, L2, L3 (4)

Solo 1, 5, 6, 11 (4)

Neanderthal L.Ch, Gi, Fe (3)

Skhūl Sk 5 (1)

Saccopastore Sac 1 (1)

Upper Palaeolithic En, Pr 3, 4, Ob 1, 2, Br 3, D.V.3,
Lau 1, Or, S.T.3, A.C.1, 4, 6, Gri, Ch, Cr 1, Ko,
C.C., Lan, G.C., F.J. (21)

Mesolithic Hoh 1, 2, Kau, Of 11, 25, Af 9, 29,
Te 1, 11, Taf 11, 17, Gra (12)

Modern populations No (110), Zu (102), Tas (86),
Es (108)

Individual cases Pet, D.I., Hot, Rh, Om 1, 2, Si,
I.E., St.R.

'ABLE 6 Matrix of generalised distances (D^2)

Analysis 6 - frontal, parietal and occipital bone

3.67					
3.43*	24.25*				
0.92*	27.54*	49.13			
3.63	N.S.	N.S.	51.95		
8.7	65.23	64.29	51.65	64.83	
h	Om 1	Om 2	Si	I.E.	St.R.

Fig. 22

Analysis 6 (frontal, parietals and occipital). Graphical representation of generalised distances (D^2) for fossil and recent material. Zulu and Pekin as reference axes.

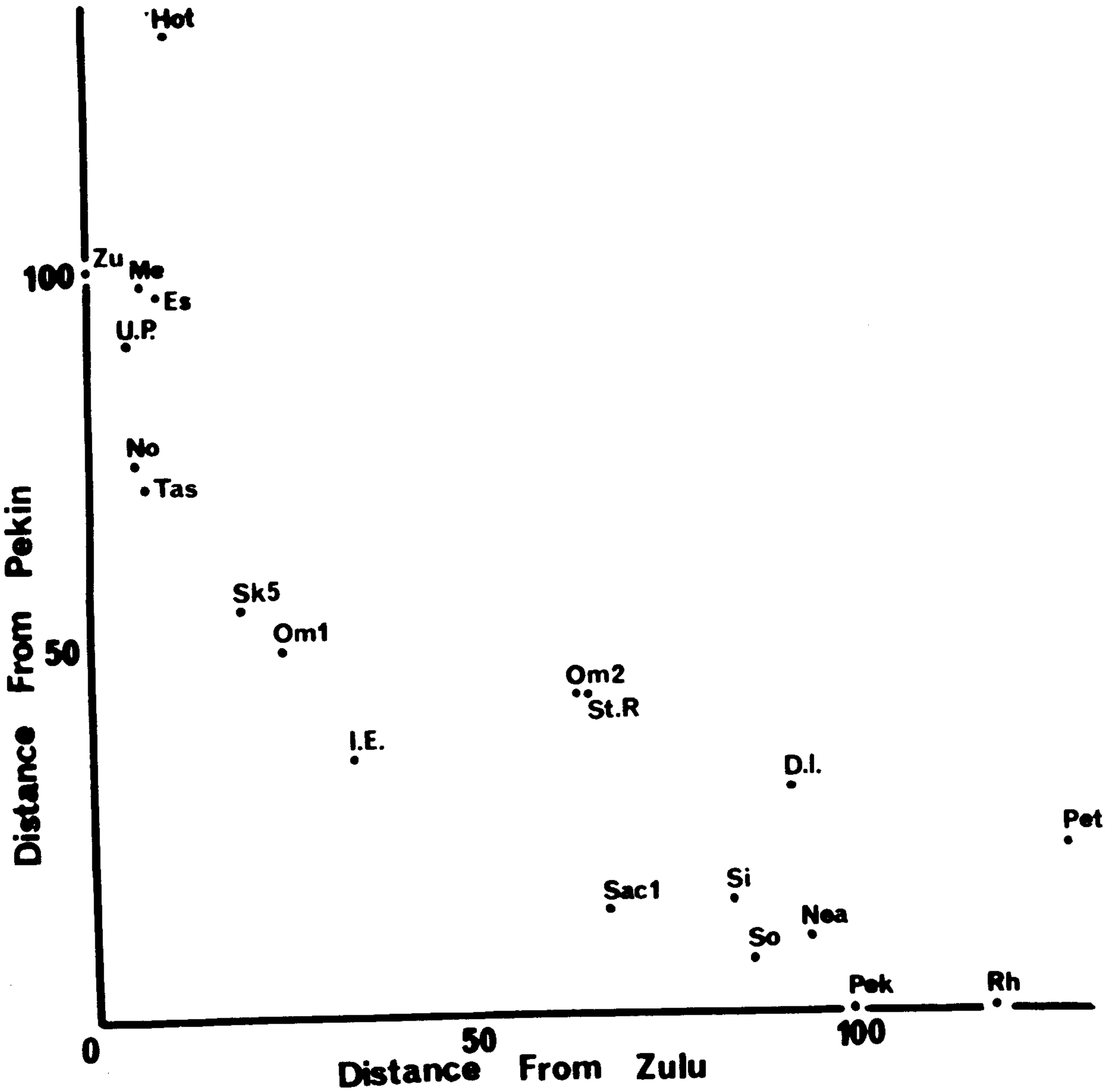
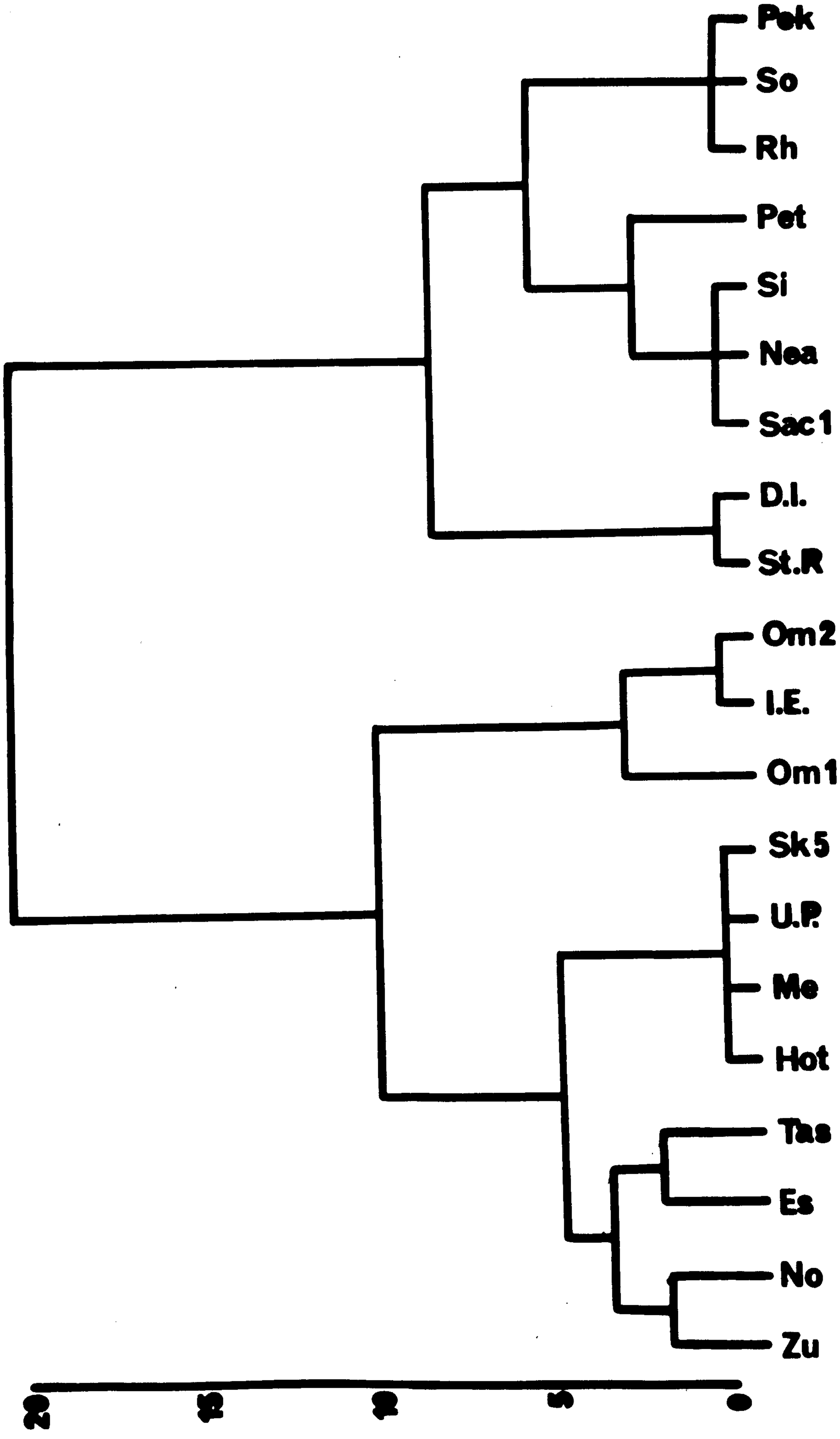

Hot
100
Zu
Me
Es
U.P.
No
Tas
Sk5
Om1
50
Om2
St.R
I.E.
D.I.
Pet
Sac1
Si
Nea
So
Pek
Rh
0
50
100
Distance From Zulu
Distance From Pekin

Fig. 23

Analysis 6 (frontal, parietals and occipital).

Dendrogram from generalised distances (D^2) matrix.


Pek
So
Rh
Pet
Si
Nea
Sac1
D.I.
St.R
Om2
I.E.
Om1
Sk5
U.P.
Me
Hot
Tas
Es
No
Zu
2
1
0

Analysis 6 Frontal, parietals and occipital. Contributions of variables to D^2 analysis in order of importance

Distance from Pekin

Solo	-STB	+SOS	-ASB	-PAC	-FRC	-OCF
Neanderthal	-STB	-XCB	-PAC	-SOS	-OCC	-PAS
Skhūl	-PAC	-PAS	-FRS	-OCF	-OCC	+SOS
Saccopastore	+FRC	-PAC	-OCC	+SOS	-FRF	-STB
Upper Palaeolithic	-PAC	-PAS	-OCC	+SOS	-FRS	-OCF
Mesolithic	-PAC	+SOS	-PAS	-OCC	-FRS	+OCS
Norse	+SOS	-PAS	-OCC	-PAC	+ASB	-OCF
Zulu	+SOS	-PAS	-PAC	-OCC	-FRS	+ASB
Tasmanian	-PAS	+SOS	-PAC	-OCC	+ASB	-FRS
Eskimo	+SOS	-PAS	-PAC	-OCC	-FRS	-OCF
Petralona	-FRF	-XCB	-OCS	-PAS	-PAF	-PAC
Djebel Irhoud	-PAC	+FRC	+OCS	-XCB	-FRS	-OCC
Hotu	-OCF	-OCC	-PAC	-PAS	+ASB	+OCS
Rhodesian*	-FRF	-PAC	-SOS	-STB	-OCS	-PAF
Omo 1	-FRC	-PAC	-PAS	-OCF	-OCC	-PAF
Omo 2	-PAC	-OCC	+SOS	-STB	-PAF	-ASB
Singa	-OCC	-FRS	-STB	-PAF	-XCB	-PAS
Iwo Eleru	+SOS	-PAC	-OCC	+FRF	-XCB	+OCS
Steinheim reconstruction	+FRC	-PAC	-OCF	+XCB	-FRS	-PAS

Analysis 6 Frontal parietals and occipital (contd.)

Distance from Neanderthal

Pekin	+STB	+XCB	+PAC	+SOS	+OCC	+PAS
Solo	+SOS	+XCB	+OCC	-FRC	-ASB	+FRS
Skhūl	+SOS	-PAS	-FRS	-PAC	+XCB	-OCF
Saccopastore*	+SOS	+FRC	+XCB	+PAS	+STB	-OCC
Upper Palaeolithic	+SOS	+XCB	-PAC	-PAS	-FRS	-OCC
Mesolithic	+SOS	-PAS	-PAC	-OCC	+XCB	+OCS
Norse	+SOS	-PAS	+XCB	+FRF	+ASB	-OCC
Zulu	+SOS	+XCB	+FRF	+ASB	-FRS	-PAS
Tasmanian	+SOS	+FRF	-PAS	+ASB	+XCB	+STB
Eskimo	+SOS	+XCB	+STB	-FRS	-PAS	+ASB
Petralona*	-OCS	-FRF	+STB	-XCB	-PAF	+ASB
Djebel Irhoud*	-PAC	+PAS	+STB	+FRC	+OCS	
Hotu	+SOS	-OCF	+XCB	+ASB	-OCC	-PAS
Rhodesian*	-OCS	+XCB	-FRF	-FRC	-PAC	-PAF
Omo 1	-FRC	+SOS	-OCF	+ASB	-PAS	-PAF
Omo 2	+SOS	-PAC	+XCB	-FRC	-OCC	-PAF
Singa*	+PAC	-OCC	-FRS	-FRC	-OCS	+SOS
Iwo Eleru	+SOS	+FRF	-PAC	-FRC	+FRS	+ASB
Steinheim reconstruction	+FRC	+XCB	-OCF	+STB	-FRS	-PAC

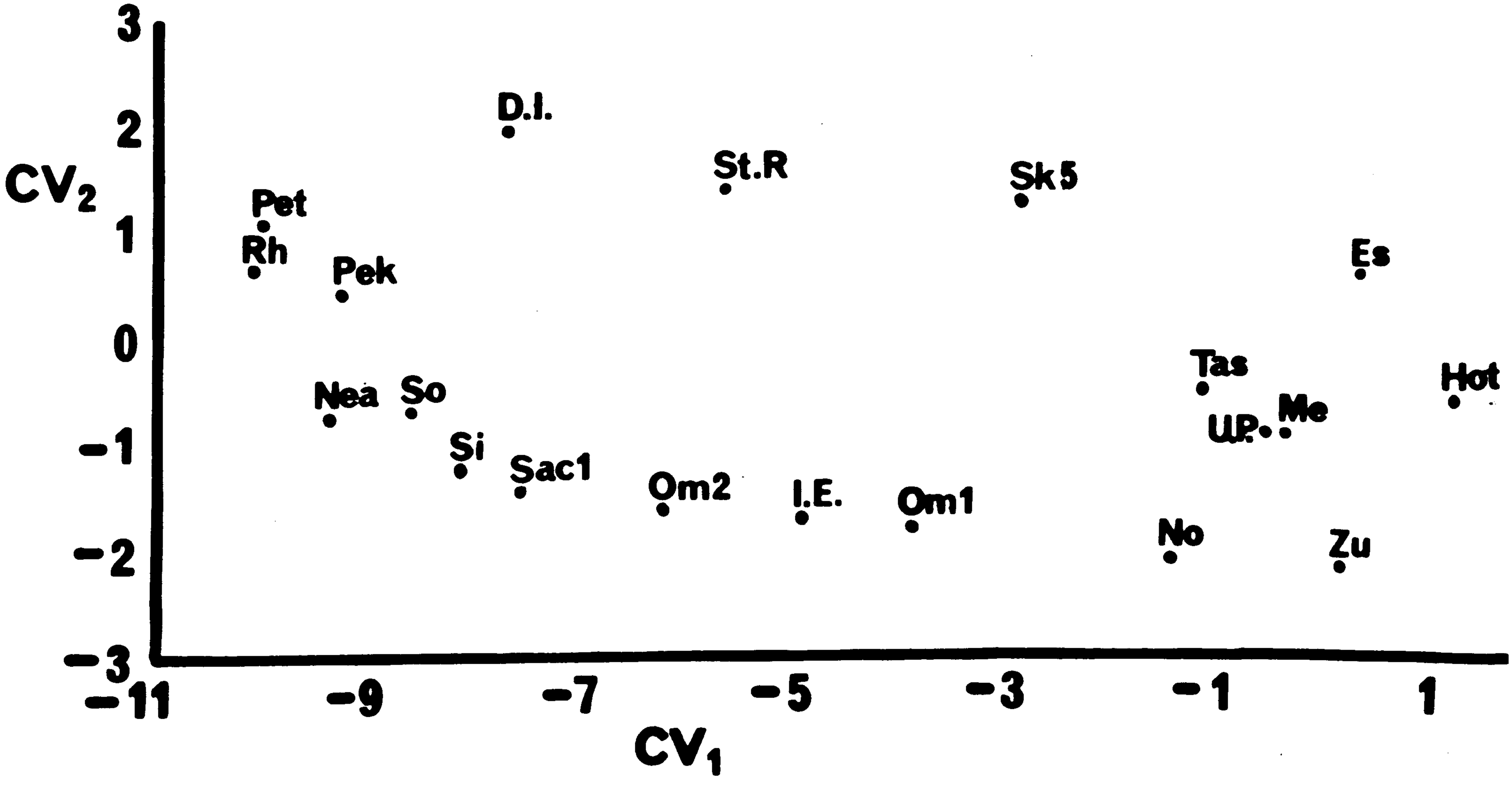
Analysis 6 Frontal, parietals and occipital (contd.)

Distance from Upper Palaeolithic

Pekin	+PAC	+PAS	+OCC	-SOS	+FRS	+OCF
Solo	+OCC	+FRS	+PAS	+PAC	-ASB	-FRF
Neanderthal	-SOS	-XCB	+PAC	+PAS	+FRS	+OCC
Skhūl*	-FRF	-SOS	+FRC	+OCC	-XCB	+PAF
Saccopastore	+PAS	+FRS	+FRC	-FRF	+PAC	+OCF
Mesolithic*	+OCS	-FRF	-XCB	+SOS	+FRC	-OCC
Norse	+PAC	+SOS	+FRS	+OCC	+OCF	-OCS
Zulu	+PAC	+FRF	+ASB	+SOS	+OCS	+XCB
Tasmanian	+STB	+PAF	+OCC	+FRF	+ASB	+FRS
Eskimo	+STB	+SOS	+PAF	+PAC	+ASB	-OCF
Petralona	-FRF	-OCS	-XCB	-SOS	+PAC	+FRS
Djebel Irhoud	+PAS	-SOS	-XCB	-FRF	+OCC	+FRC
Hotu*	-OCF	+ASB	-FRF	-OCC	+SOS	+OCS
Rhodesian	-SOS	-FRF	-OCS	+FRS	+OCC	+PAS
Omo 1	-FRC	-XCB	-SOS	-FRF	-STB	-PAF
Omo 2	+PAS	+FRS	-ASB	-OCS	+OCF	-FRC
Singa	+PAC	-SOS	-XCB	+OCC	-ASB	+PAS
Iwo Eleru	+FRS	-XCB	+PAS	+OCC	+OCF	-FRC
Steinheim reconstruction	+FRC	-SOS	+OCC	+PAS	+PAF	-ASB

Fig. 24

Analysis 6 (frontal, parietals and occipital). Plot of canonical variates 1 and 2 for fossil and recent material.


3
2
1
0
−1
−2
−3
CV2
D.I.
St.R
Sk5
Pet
Rh
Pek
Es
Tas
Hot
U.P.
Me
Nea
So
Si
Sac1
Om2
I.E.
Om1
No
Zu
−11
−9
−7
−5
−3
−1
1
CV1

Analysis 7 Cranial vault - 13 variables (Figs 25-27)

Variables used (13)

GOL, XCB, AUB, ASB, FMB, SOS, FRC, FRS, FRF,
PAC, PAS, PAF, VRR

Sample

Pekin E, L.2 (2)

Solo So 11 (1)

Neanderthal Sp 1, 2, M.C., L.Ch, Qu, Gi, Mo, Fe (8)

Middle-east Neanderthals Am, Tab (2)

Skhūl Sk 5

Upper Palaeolithic Pr 3, 4, Ob 1, 2, Br 3, Lau 1, 5,
D.V.3., Or, S.T.3, A.C.1, 4, 6, Gri, Ch, Cr 1,
2, 3, Ko, L.B.2, C.C., Lan, C.C. (23)

Mesolithic Hoh 1, 2, Kau, Of 25, Af 9, 10, 29, 32,
Te 1, 11, Taf 11, 17, Gra (13)

Modern populations No (110), Zu (102), Tas (86), Es (108)

Individual cases Co, Pet, D.I., Hot, Rh, Om 2, Si,
St, I.E., St.R.

Pek														
So	24.35													
Nea	38.57	N.S.												
M.E.N.	33.79	N.S.	N.S.											
Sk 5	84.60	40.07	33.86	17.87*										
U.P.	110.74	57.41	55.47	46.74	15.27*									
Me	119.4	59.17	60.09	48.89	12.56*	2.08								
No	94.88	52.08	53.06	51.23	25.24	7.88	7.71							
Zu	137.97	77.63	74.58	73.15	25.26	8.79	10.35	9.72						
Tas	99.05	59.48	51.30	47.71	17.42	5.75	7.07	4.48	6.49					
Es	112.98	68.32	76.83	64.46	28.21	6.94	6.94	10.13	14.11	10.41				
Co	142.0	76.0	85.07	78.63	63.89	85.77	73.45	95.68	109.47	93.85	79.79			
Pet	49.09	32.47	37.10	33.03	40.5	102.74	104.7	109.78	137.77	109.25	115.78	100.5		
D.I.	60.26	26.4*	23.89	N.S.	21.04*	61.97	60.7	78.19	87.37	62.71	84.33	104.3	26.68*	
Hot	117.9	51.01	54.11	52.4	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	52.1	106.9	74.6
Rh	62.82	N.S.	17.01	16.91*	23.48*	81.06	81.25	91.28	99.67	82.45	107.08	57.87	31.52	N.S.
Om 2	85.2	N.S.	33.45	31.34	42.37	32.35	36.06	40.68	53.50	45.91	47.76	76.40	82.7	38.59
Si	70.38	N.S.	18.04	19.02*	43.53	74.96	71.34	68.20	78.42	67.77	98.18	116.2	73.72	41.56
St	63.19	39.82	19.77	16.43*	58.77	101.54	105.5	98.38	109.57	92.35	127.18	108.2	79.6	53.37
I.E.	63.69	22.14*	35.23	49.78	27.94*	40.07	42.55	27.73	45.40	31.97	48.31	106.4	59.53	48.07
St.R.	75.88	42.26	23.20	N.S.	22.55*	43.15	47.82	56.86	61.94	44.18	63.97	97.60	71.82	19.26*
	Pek	So	Nea	M.E.N.	Sk 5	U.P.	Me	No	Zu	Tas	Es	Co	Pet	D.I.

Fig. 25

Analysis 7 (vault - 13 variables). Graphical representation of generalised distances (D^2) for fossil and recent material. Pekin and Zulu as reference axes.

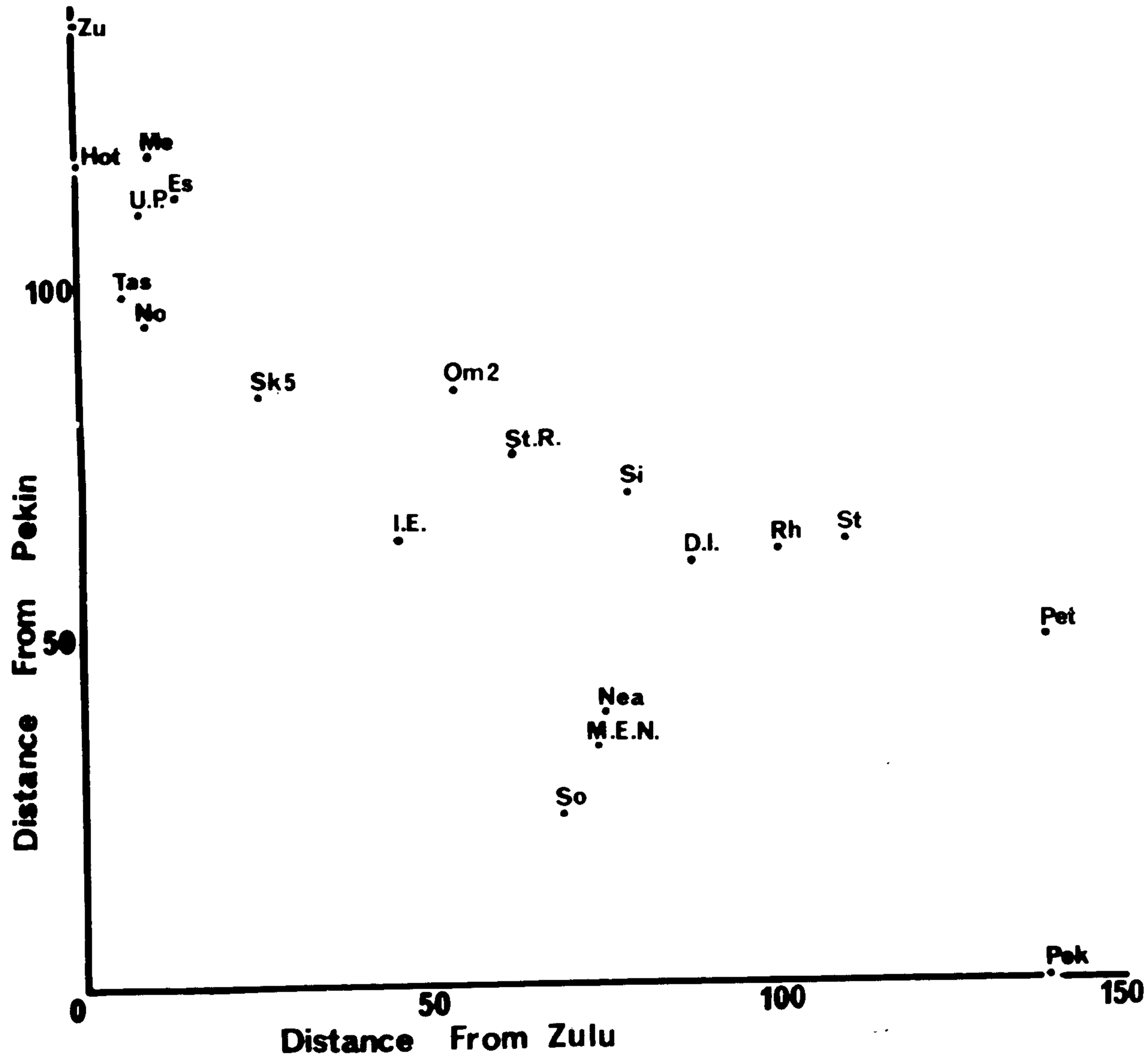
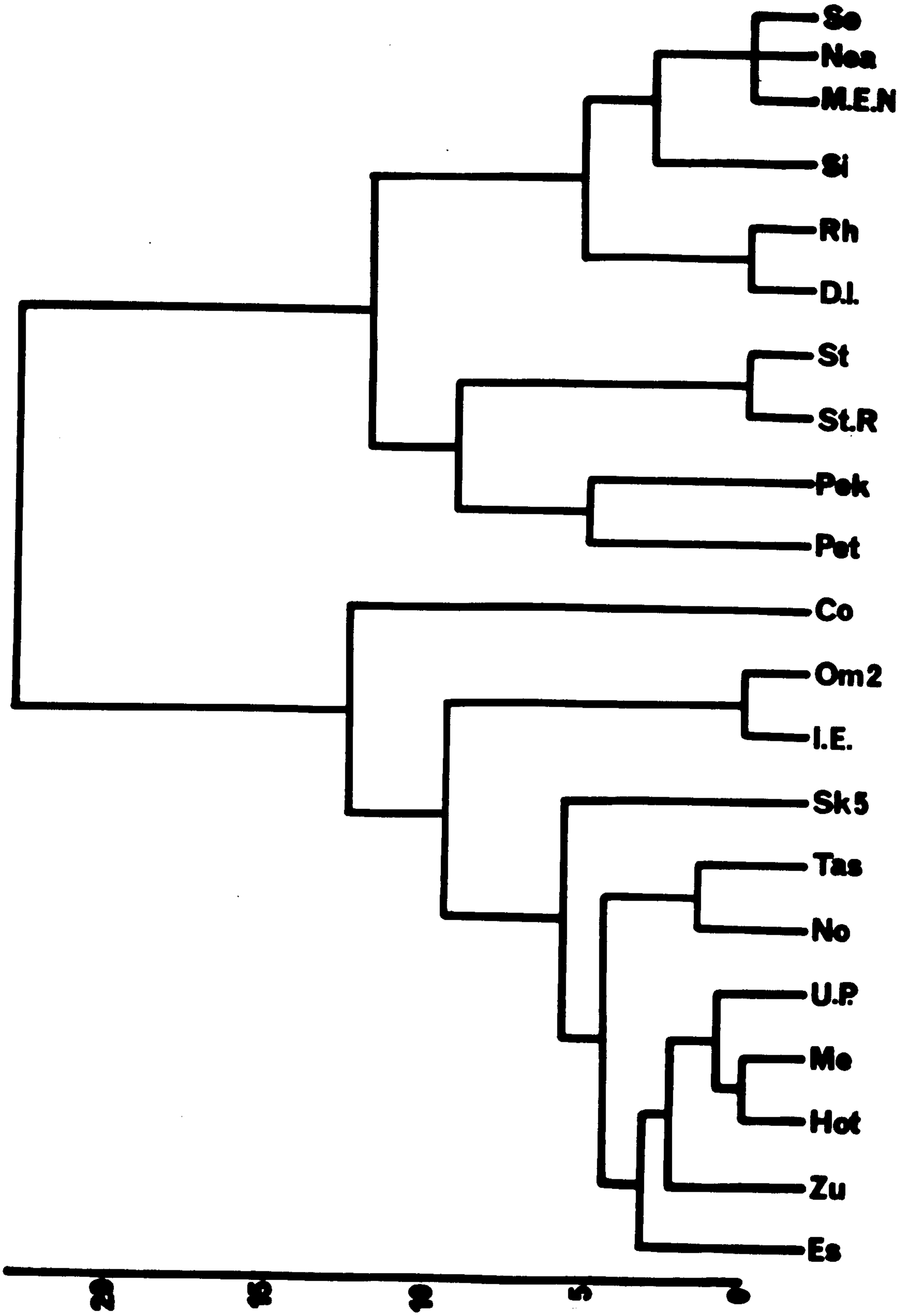

Zu
Hot
Me
U.P.
Es
100
Tas
No
Sk5
Om2
St.R.
Si
I.E.
D.I.
Rh
St
Pet
50
Nea
M.E.N.
So
Pek
0
50
100
150
Distance From Zulu
Distance From Pekin

Fig. 26

Analysis 7 (vault - 13 variables). Dendrogram from generalised distances (D^2) matrix.


So
Nos
M.E.N
Si
Rh
D.I.
St
St.R
Pek
Pet
Co
Om2
I.E.
Sk5
Tas
No
U.P.
Mo
Hot
Zu
Es

Analysis 7 Cranial vault - 13 variables Contributions of variables to D^2 analysis in order of importance

Distance from Pekin

Solo -VRR -PAF -FMB +FRS -ASB -PAC

Neanderthal -VRR -FMB +AUB -XCB -PAC -SOS

Middle-east Neanderthals -VRR -PAC -FMB +AUB -ASB -XCB

Skhūl -VRR -PAC -FMB +AUB +SOS -FRS

Upper Palaeolithic -VRR -PAC +AUB +SOS -PAF -FRS

Mesolithic -VRR -PAC +SOS +AUB -PAF -FRS

Norse -VRR +SOS +AUB -PAC -PAS -PAF

Zulu -VRR +AUB +SOS -PAC +FRF +ASB

Tasmanian -VRR -PAC +AUB +SOS +GOL +FRF

Eskimo -VRR +SOS -PAC +AUB +ASB +XCB

Cohuna -VRR -FRF -PAC +AUB +XCB -FMB

Petralona -FMB -VRR -FRF -PAC -XCB -PAF

Djebel Irhoud -PAC -VRR -FMB -XCB -FRF -FRS

Hotu -VRR +AUB -PAC +SOS -PAF +ASB

Rhodesian -FMB -PAC -VRR -FRF -FRC -PAF

Omo 2 -VRR -PAC -PAF +AUB +SOS -FMB

Singa -VRR -FMB +AUB -XCB -FRC -PAF

Steinheim +AUB -VRR -FMB -SOS +FRC -FRF

Iwo Eleru +SOS -PAC -FMB -VRR -FRC +FRS

Steinheim reconstruction +AUB -VRR +FRC -PAC -FMB +GOL

Analysis 7 Cranial vault - 13 variables (contd.)

Distance from Neanderthal

Pekin	+VRR	+FMB	-AUB	+XCB	+PAC	+SOS
Solo*	+PAS	+SOS	+XCB	-PAF	-ASB	-AUB
Middle-east Neanderthals*	-ASB	+FRC	-FRS	+XCB	+GOL	+PAF
Skhūl	+SOS	-PAC	-FRS	+GOL	+XCB	-FMB
Upper Palaeolithic	+SOS	-PAC	+XCB	-FRS	-VRR	+GOL
Mesolithic	+SOS	+GOL	-PAC	-VRR	-FRS	+XCB
Norse	+SOS	+GOL	+XCB	+FRF	+FMB	-PAS
Zulu	+SOS	+GOL	+XCB	+FRF	-FRS	+ASB
Tasmanian	+SOS	+GOL	+XCB	+FRF	-FRS	+ASB
Eskimo	+SOS	+XCB	+GOL	-FRS	-VRR	+FMB
Cohuna	-FRF	+XCB	-VRR	+SOS	-FRC	-PAC
Petralona	-AUB	-FMB	-FRF	+FRC	-GOL	-PAF
Djebel Irhoud	-PAC	+PAS	+GOL	-AUB	-FMB	+FRC
Hotu	+SOS	+XCB	+GOL	-PAF	+ASB	-VRR
Rhodesian	-FMB	-FRF	-FRC	-PAC	+XCB	-ASB
Omo 2	+SOS	-PAC	+XCB	-VRR	-PAF	-ASB
Singa	+GOL	-FRC	-FRS	+PAC	+PAS	-FMB
Steinheim	+AUB	+FRC	+PAC	+VRR	-SOS	-FRS
Iwo Eleru	+SOS	-PAC	+FRF	+VRR	+FRS	-FRC
Steinheim reconstruction	+FRC	+XCB	+AUB	+GOL	-FRS	-PAC

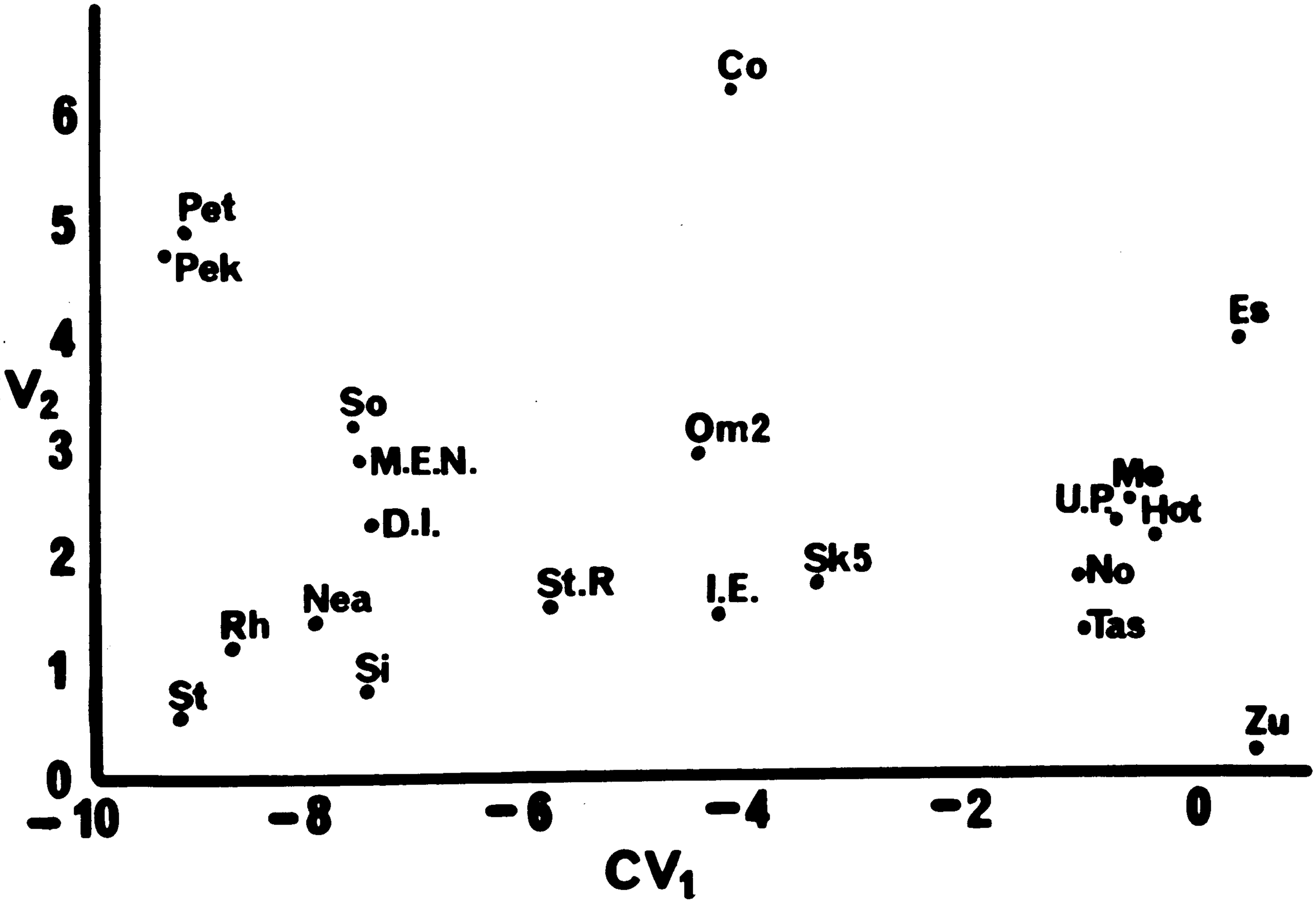
Analysis 7 Cranial vault - 13 variables (contd.)

Distance from Upper Palaeolithic

Pekin	+VRR	+PAC	-AUB	-SOS	+PAF	+FRS
Solo	+PAC	+PAS	+FRS	-ASB	+VRR	-FRF
Neanderthal	-SOS	+PAC	-XCB	+FRS	+VRR	-GOL
Middle-east Neanderthals	-SOS	-ASB	+PAC	-FRF	+VRR	+FRC
Skhūl	-FMB	-FRF	+VRR	+PAF	+FRC	-ASB
Mesolithic	+GOL	-FRF	+SOS	-XCB	+FRS	+AUB
Norse	+PAC	+VRR	+FRS	+SOS	+FMB	+AUB
Zulu	+AUB	+GOL	+FRF	+SOS	+ASB	+PAC
Tasmanian	+VRR	+GOL	+PAF	+FRS	+FRF	+ASB
Eskimo	+SOS	+XCB	+PAC	+FMB	+PAF	+ASB
Cohuna	-FRF	+FRS	+PAF	+XCB	-SOS	-FRC
Petralona	-AUB	-FRF	-FMB	+VRR	-GOL	-SOS
Djebel Irhoud	+PAS	-SOS	-FMB	-XCB	+VRR	-FRF
Hotu*	+AUB	-FRF	+ASB	+FRS	-PAF	+PAC
Rhodesian	-FMB	-SOS	-FRF	+VRR	+FRS	+PAS
Omo 2	+PAS	+FRS	-GOL	-ASB	-FRF	-PAF
Singa	+PAC	-SOS	-XCB	-FMB	+PAS	-ASB
Steinheim	-SOS	+PAC	+VRR	+AUB	+FRC	-FRF
Iwo Eleru	+FRS	+VRR	-XCB	-FMB	-GOL	+PAS
Steinheim reconstruction	+FRC	-SOS	+AUB	+PAS	+PAF	-ASB

Fig. 27

Analysis 7 (vault - 13 variables). Plot of canonical variates 1 and 2 for fossil and recent material.


Co
Pet
Pek
Es
So
Om2
M.E.N.
Me
U.P.
Hot
D.I.
Sk5
No
St.R
I.E.
Nea
Rh
Tas
Si
St
Zu
6
5
4
3
2
1
0
CV2
−10
−8
−6
−4
−2
0
CV1

Analysis 8 Cranial vault - 17 variables (Figs 28-30)

Variables used (17)

GOL, XCB, STB, AUB, ASB, FMB, SOS, FRC, FRS, FRF, PAC, PAS, PAF, OCC, OCS, OCF, VRR

Sample

Pekin E, L 2 (2)

Solo Solo 11 (1)

Neanderthal L.Ch, Gi, Fe (3)

Skhūl Sk.5 (1)

Upper Palaeolithic Pr 3, 4, Ob 1, 2, Br 3, D.V.3, Lau 1, Or, S.T.3, A.C.1, 4, 6, Gri, Ch, Cr 1, Ko, C.C., Lan, G.C. (19)

Mesolithic Hoh 1, 2, Kau, Of 25, Af 9, 29 Te 1, 11, Taf 11, 17, Gra (11)

Modern populations No (110), Zu (102), Tas (86), Es (108)

Individual cases Pet, D.I., Hot, Rh, Om 2, Si, I.E., St.R.

TABLE 8 Matrix of generalised distances (D^2)

Analysis 8 - Cranial vault

	Pek	So	Nea	Sk.5	U.P.	Me	No	Zu	Tas	Es	Pet	D.I.	Hot	Rh	Om 2	Si	I.E.	St.R.
Pek																		
So	40.30																	
Nea	34.49	15.95*																
Sk 5	96.40	78.50	64.05															
U.P.	118.01	92.91	82.53	17.67														
Me	128.95	102.66	86.93	15.20*	1.53*													
No	99.75	79.48	74.80	27.65	9.49	9.60												
Zu	143.43	107.53	101.07	27.61	9.09	9.06	11.00											
Tas	105.40	91.30	77.37	15.79*	7.66	8.19	8.18	8.89										
Es	123.64	105.44	111.88	27.31	8.31	9.82	16.20	17.07	11.70									
Pet	60.15	52.74	52.79	50.14	122.21	130.55	120.35	155.43	120.9	135.04								
D.I.	57.27	42.16	20.74*	26.36*	68.39	67.27	83.95	90.83	63.37	87.54	37.74							
Hot	154.0	116.0	109.13	30.44	N.S.	N.S.	15.71*	13.10*	22.80	14.66 *	162.6	105.4						
Rh	78.20	26.21*	34.47	41.35	110.81	115.0	107.75	124.13	101.40	136.54	27.1*	31.63*	144.7					
Om 2	85.20	N.S.	37.78	68.90	48.95	54.60	49.60	66.05	63.03	72.35	96.8	46.13	75.50	52.42				
Si	85.20	60.47	39.41	51.54	97.71	90.55	80.36	95.73	80.10	119.84	75.20	55.42	121.0	N.S.	81.0			
I.E.	58.89	35.53	45.05	34.50	41.78	46.37	27.28	45.21	34.65	53.43	72.20	45.62	60.21	67.20	N.S.	86.50		
St.R.	85.20	47.78	27.04	31.92*	52.85	58.11	65.48	68.57	51.85	73.07	88.6	21.72*	68.0	62.2	58.33	78.50	86.10	

Fig. 28

Analysis 8 (vault - 17 variables). Graphical representation of generalised distances (D^2) for fossil and recent material. Neanderthal and Upper Palaeolithic as reference axes.

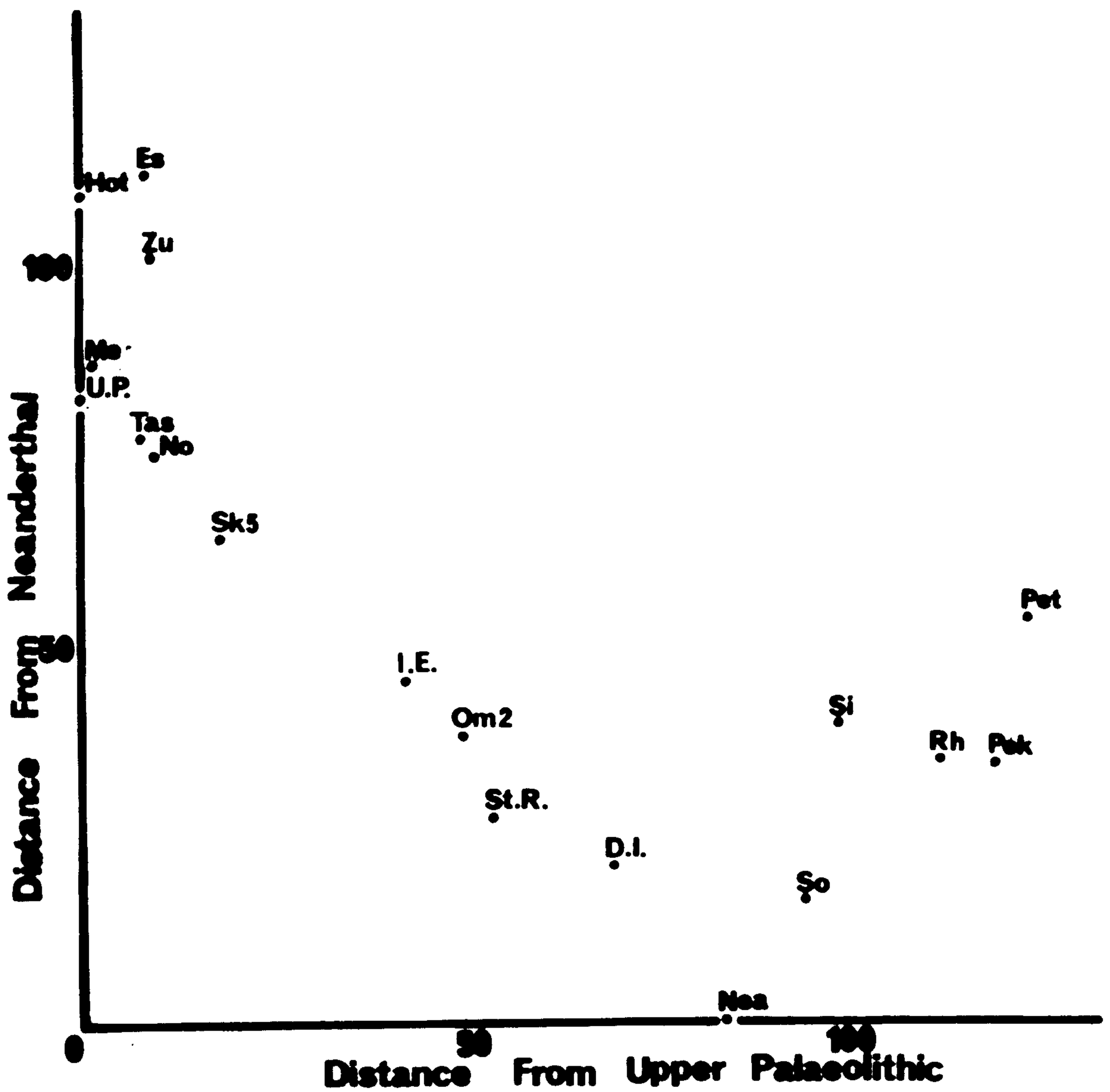
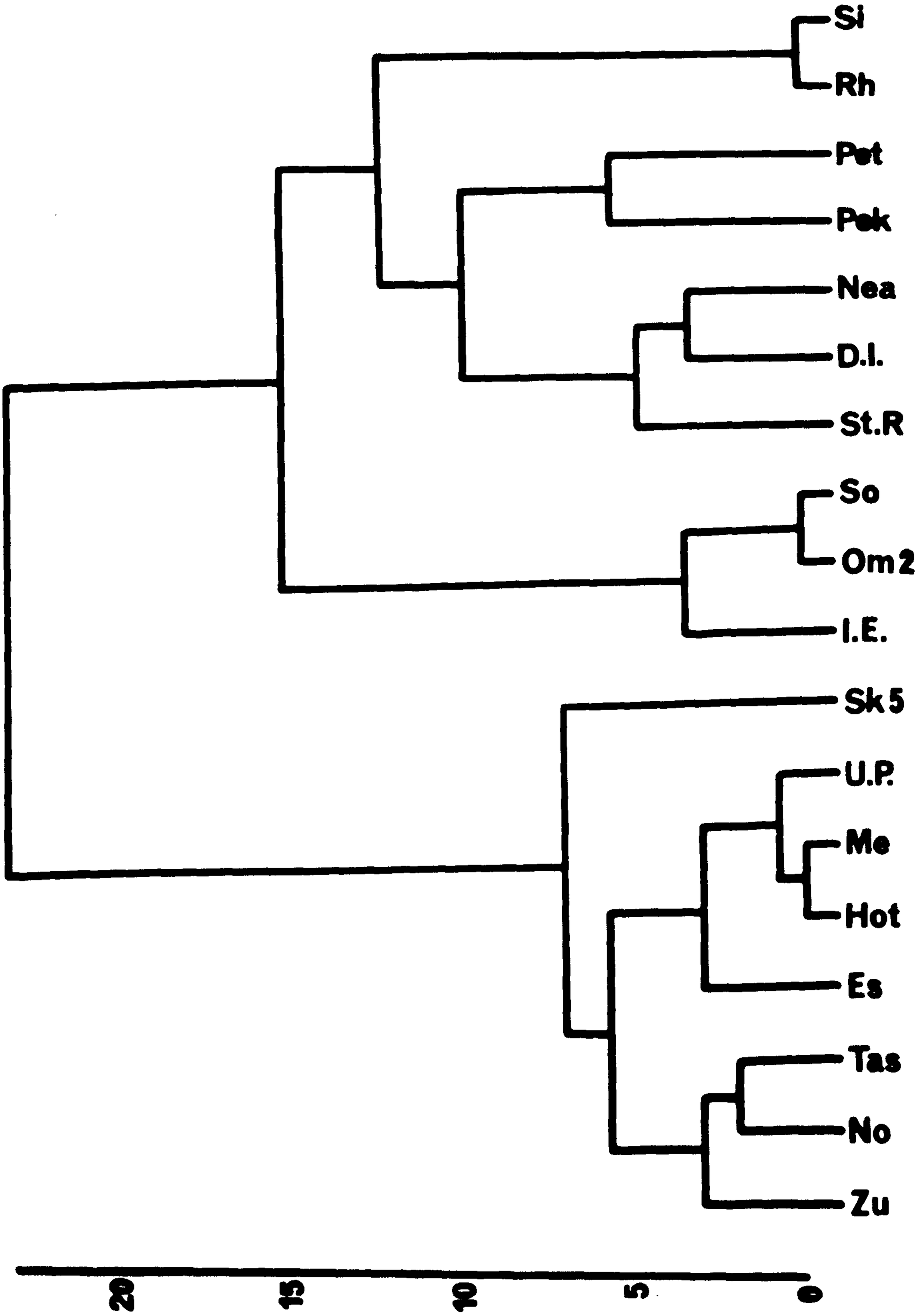

Es
Hot
Zu
Mo
U.P.
Tas
No
Sk5
Pet
I.E.
Om2
Si
Rh
Pak
St.R.
D.I.
So
Nea
Neanderthal
Distance From
Distance From Upper Palaeolithic

Fig. 29

Analysis 8 (vault - 17 variables). Dendrogram from generalised distances (D^2) matrix.


Si
Rh
Pet
Pek
Nea
D.I.
St.R
So
Om2
I.E.
Sk5
U.P.
Me
Hot
Es
Tas
No
Zu
20
15
10
5
0

Analysis 8 Cranial vault - 17 variables Contributions of variables to D^2 analysis in order of importance

Distance from Pekin

Solo	-VRR	-PAF	-FMB	-OCF	+FRS	-STB
Neanderthal	-VRR	-XCB	-FMB	+AUB	-STB	-PAC
Skhūl	-PAC	-FMB	-VRR	-PAS	+AUB	-OCF
Upper Palaeolithic	-VRR	-PAC	+SOS	+AUB	-OCF	-OCC
Mesolithic	-VRR	-PAC	+AUB	+SOS	-OCC	-FRS
Norse	-VRR	+SOS	+AUB	-PAC	-PAS	+GOL
Zulu	-VRR	+AUB	-PAC	+SOS	+ASB	+FRF
Tasmanian	-VRR	-PAC	+AUB	+SOS	+GOL	+ASB
Eskimo	-VRR	+SOS	-PAC	+AUB	-OCF	+ASB
Petralona	-FMB	-VRR	-OCS	-FRF	-PAC	-PAF
Djebel Irhoud	-PAC	-VRR	-FMB	-XCB	-OCF	-FRS
Hotu	-OCF	-VRR	-PAC	+AUB	+SOS	-OCC
Rhodesian	-FMB	-VRR	-PAC	-OCS	-FRC	-FRF
Omo 2	-VRR	-PAC	-PAF	+AUB	+SOS	-STB
Singa	-VRR	-FMB	+AUB	-XCB	-FRC	-OCC
Iwo Eleru	+SOS	-PAC	-FMB	-VRR	-FRC	+FRS
Steinheim reconstruction	+AUB	-VRR	+FRC	-PAC	-OCF	-FMB

Analysis 8 Cranial vault - 17 variables (contd.)

Distance from Neanderthal

Pekin	+VRR	+XCB	+FMB	-AUB	+STB	+PAC
Solo	+SOS	+XCB	+OCC	+PAS	-PAF	-OCF
Skhūl	+SOS	-PAC	+GOL	-PAS	-FRS	-FMB
Upper Palaeolithic	+SOS	+XCB	-PAC	-FRS	-PAS	+GOL
Mesolithic	+SOS	+GOL	-PAC	+XCB	-OCC	-FRS
Norse	+SOS	+GOL	+XCB	-PAS	+FRF	+ASB
Zulu	+SOS	+GOL	+XCB	+FRF	+ASB	-FRS
Tasmanian	+SOS	+GOL	+XCB	+FRF	+STB	-PAS
Eskimo	+SOS	+XCB	+GOL	+STB	-FRS	+ASB
Petralona	-AUB	-FMB	-OCS	-FRF	+STB	+SOS
Djebel Irhoud	-PAC	+PAS	-FMB	+GOL	+STB	-FRS
Hotu	+SOS	-OCF	-OCC	+XCB	+ASB	-PAC
Rhodesian	-FMB	-OCS	-FRC	+XCB	-FRF	-PAC
Omo 2	+SOS	+XCB	-PAC	-VRR	-FRC	-PAF
Singa	+GOL	-FRC	-OCC	-OCS	-FRS	-FMB
Iwo Eleru	+SOS	+FRF	-PAC	-FRC	+FRS	+VRR
Steinheim reconstruction	+FRC	+XCB	+AUB	-OCF	+STB	+GOL

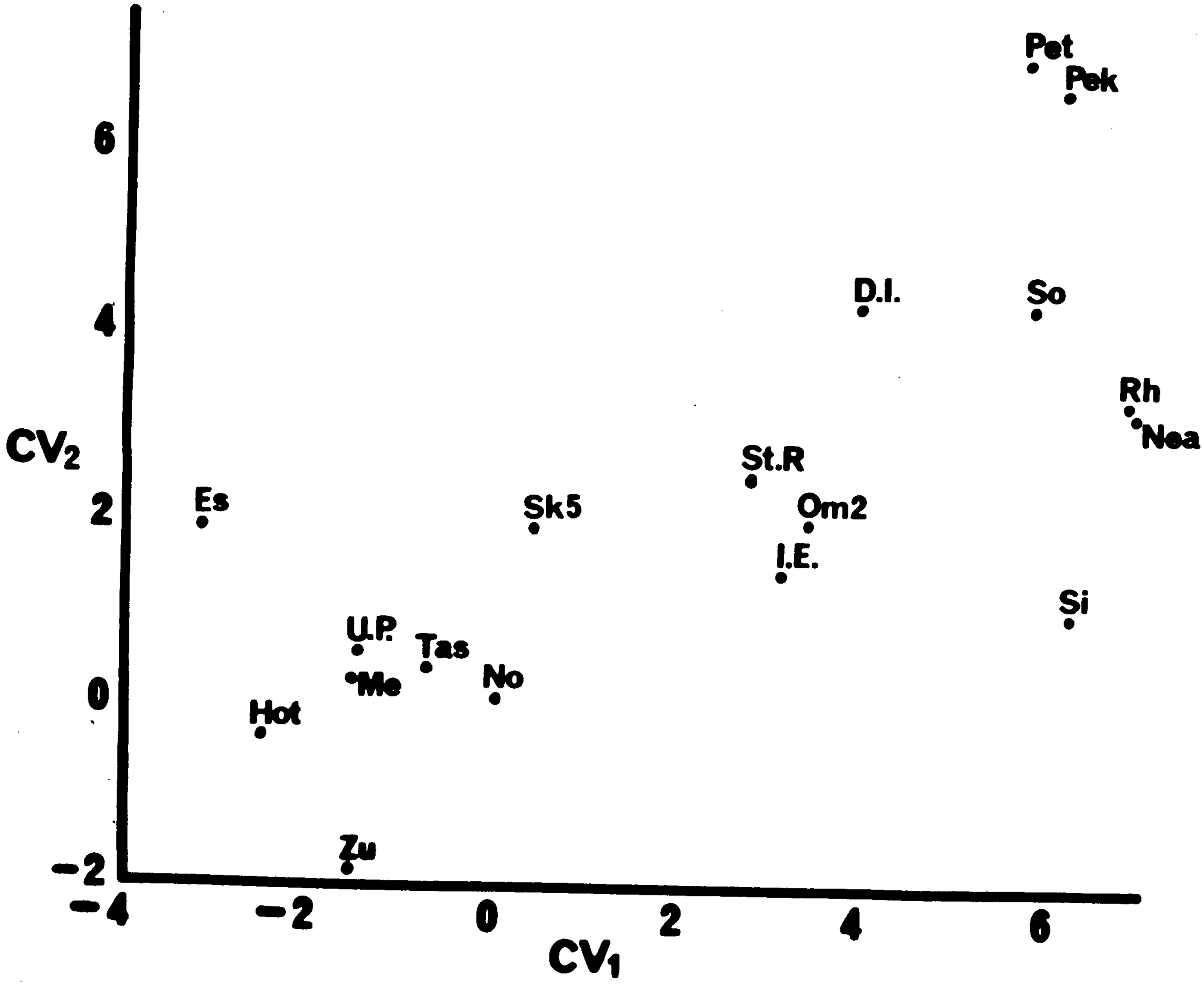
Analysis 8 Cranial vault - 17 variables (contd.)

Distance from Upper Palaeolithic

Pekin	+VRR	+PAC	-SOS	-AUB	+OCF	+OCC
Solo	+PAC	+PAS	+OCC	+FRS	-ASB	-GOL
Neanderthal	-SOS	-XCB	+PAC	+FRS	+PAS	-GOL
Skhūl	-FMB	-FRF	+VRR	-XCB	-ASB	+PAF
Mesolithic	+GOL	-FRF	+AUB	-XCB	+OCS	+SOS
Norse	+PAC	+VRR	+FRS	+SOS	+AUB	+GOL
Zulu	+AUB	+FRF	+PAC	+GOL	+SOS	+ASB
Tasmanian	+GOL	+STB	+AUB	+PAF	+VRR	+FRS
Eskimo	+STB	+SOS	+PAF	+GOL	+ASB	+PAC
Petralona	-FRF	-FMB	-AUB	-OCS	-XCB	-SOS
Djebel Irhoud	+PAS	-SOS	-FMB	-XCB	-FRF	+OCC
Hotu*	-OCF	+AUB	+ASB	-FRF	-OCC	+FMB
Rhodesian	-FMB	-SOS	-FRF	-OCS	+FRS	+PAS
Omo 2	+PAS	+FRS	-GOL	-ASB	+OCF	-OCS
Singa	+PAC	-SOS	-XCB	-FMB	-OCS	-ASB
Iwo Eleru	+FRS	+VRR	-XCB	-FMB	-GOL	+PAS
Steinheim reconstruction	+FRC	-SOS	+OCC	+PAS	+AUB	+PAC

Fig. 30

Analysis 8 (vault - 17 variables). Plot of canonical variates 1 and 2 for fossil and recent material.


Pet
Pek
D.I.
So
Rh
Nea
St.R
Om2
I.E.
Si
Es
Sk5
U.P.
Tas
Me
No
Hot
Zu
6
4
2
0
−2
−4
−2
0
2
4
6
CV2
CV1

Analysis 9 Radius measurements (Figs 31-33)

Variables used (9)

VRR, NAR, SSR, PRR, ZOR, FMR, EKR, ZMR, AVR

Sample

Neanderthal M.C., L.Ch, Gi, Fe (4)

Middle-east Neanderthals Am (1)

Skhūl Sk.5 (1)

Saccopastore Sac 2

Upper Palaeolithic Pr 3, Ob 1, 2, Lau 1, Or, S.T.3., A.C. 1, 4, 6, Gri, Ch, Cr 1, 2, Ko, C.C., G.C. (16)

Mesolithic Hoh 1, 2, Kau, Af 9, 10, 29, 32, Te 1, 11, Taf 11, 17, Gra (12)

Modern populations No (110), Zu (102), Tas (86), Es (108)

Individual cases Co, Pet, D.I., Hot, Rh, St.R.

TABLE 9 Matrix of generalised distances (D^2)

Analysis 9 Radius measurements

Nea														
Am	N.S.													
Sk 5	39.25	34.48												
Sac 2	N.S.	N.S.	N.S.											
U.P.	48.76	22.02	21.76	21.95										
Me	46.08	22.92	25.5	25.69	N.S.									
No	43.13	24.33	25.78	22.85	4.60	4.05								
Zu	36.61	18.54	15.90	18.09	9.14	8.63	4.54							
Tas	30.09	20.84	8.41*	13.22	9.81	10.19	4.96	4.22						
Es	54.70	23.62	17.91	22.89	3.96	8.15	9.93	11.12	13.49					
Co	42.91	17.91*	22.25*	N.S.	19.93	22.24	23.67	10.78*	20.60	23.24				
Pet	32.39	17.15*	16.7*	N.S.	40.11	50.39	39.67	29.45	21.87	28.56	31.8			
D.I.	N.S.	N.S.	N.S.	N.S.	32.94	35.67	28.41	12.48*	11.67*	27.83	21.39*	N.S.		
Hot	34.64	N.S.	N.S.	15.96*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	17.13*	28.31	N.S.	
Rh	N.S.	N.S.	33.73	N.S.	65.95	64.67	58.03	36.88	37.25	69.07	30.93	30.92	N.S.	45.61
St.R.	21.39	16.40*	N.S.	N.S.	31.12	31.96	21.25	15.97	10.84*	21.53	48.93	N.S.	N.S.	N.S.
	Nea	Am	Sk 5	Sac 2	U.P.	Me	No	Zu	Tas	Es	Co	Pet	D.I.	Hot

Fig. 31

Analysis 9 (EAM - radii measurements). Graphical representation of generalised distances (D^2) for fossil and recent material. Mesolithic and Petralona as reference axes.

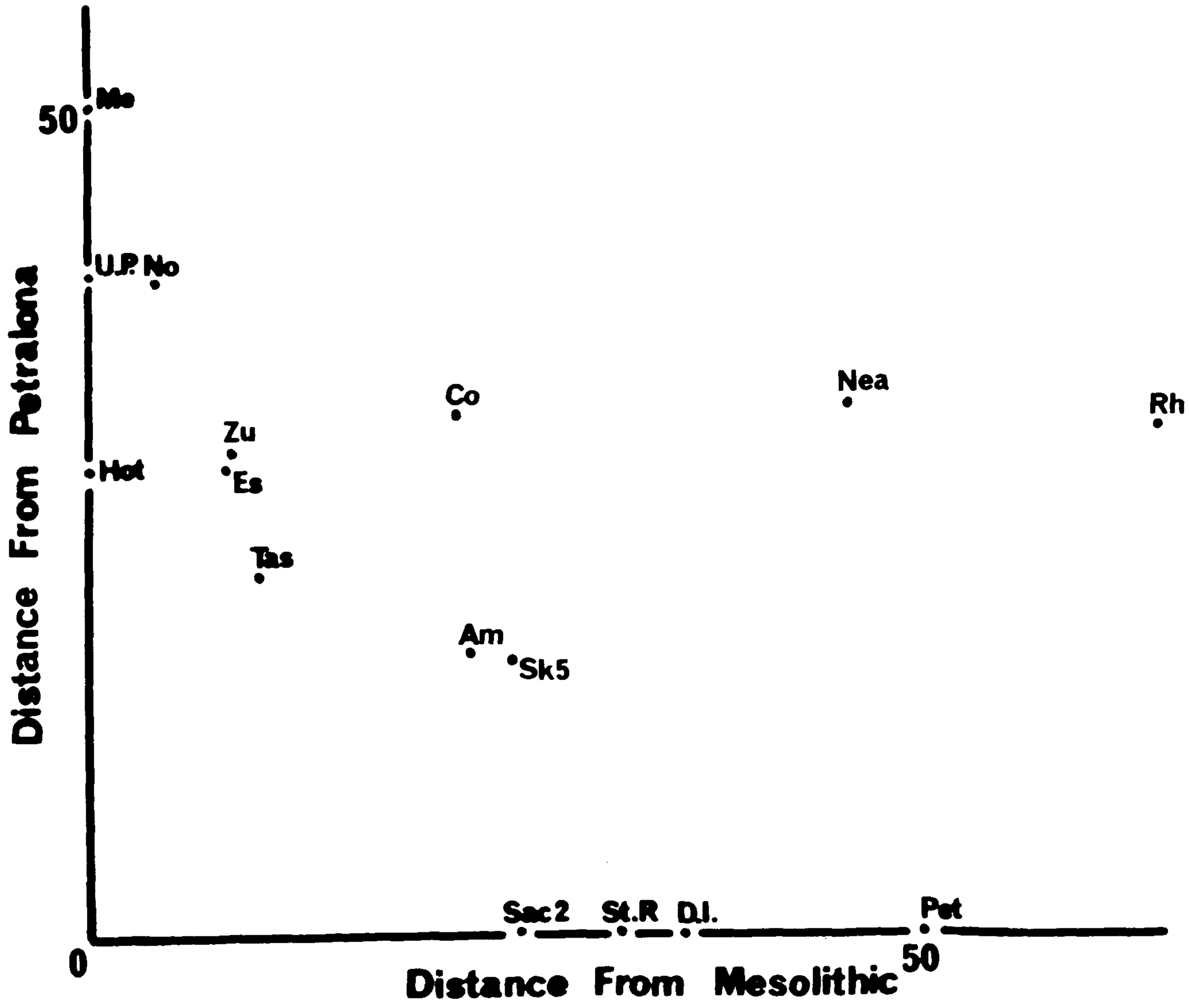
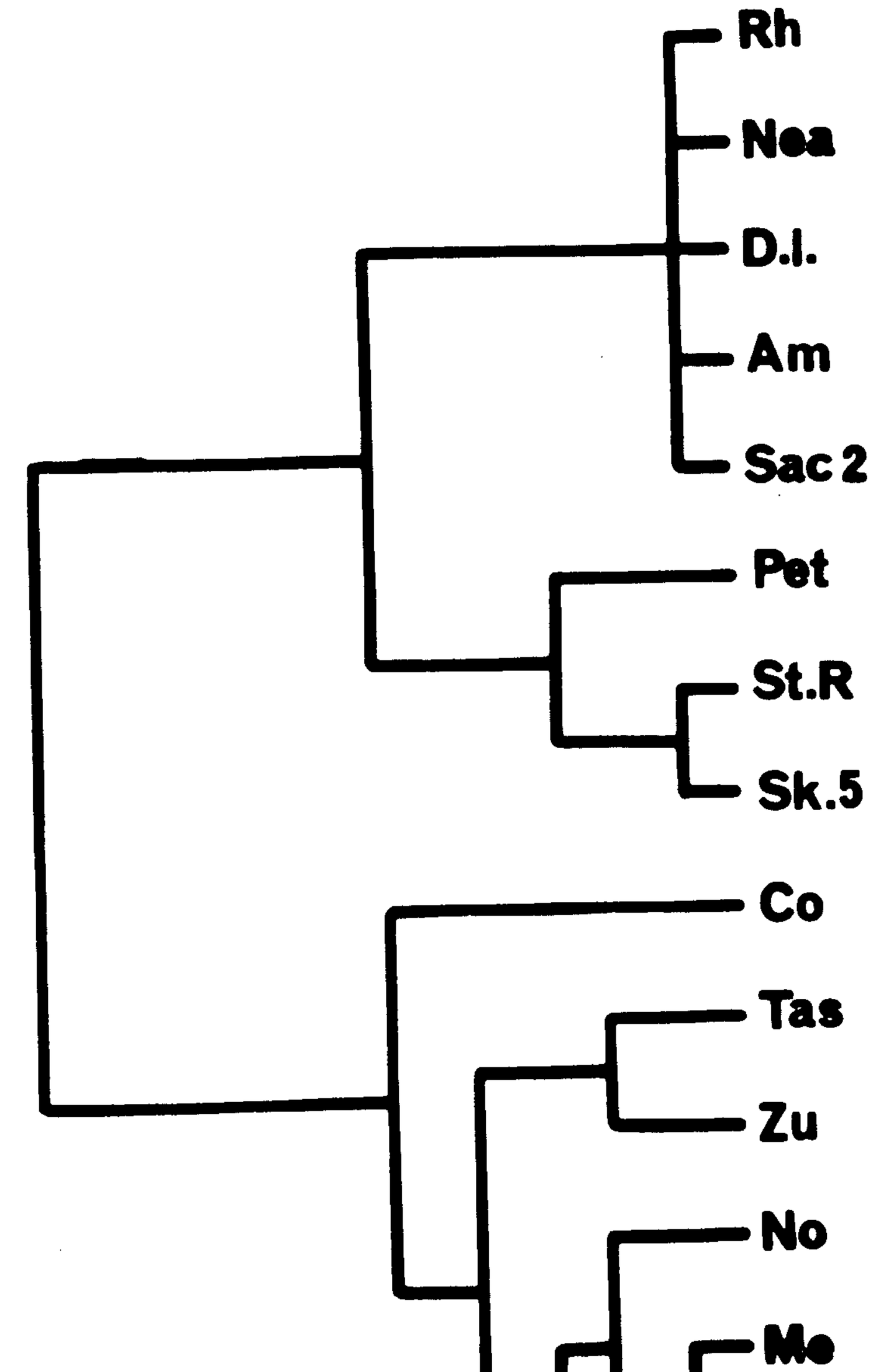

50
Me
U.P.
No
Hot
Zu
Es
Tas
Co
Nea
Rh
Am
Sk5
Sec2
St.R
D.I.
Pet
0
50
Distance From Petralona
Distance From Mesolithic

Fig. 32

Analysis 9 (EAM - radii measurements). Dendrogram from generalised distances (D^2) matrix.


Rh
Nea
D.I.
Am
Sac 2
Pet
St.R
Sk.5
Co
Tas
Zu
No
Me
Hot
U.P.
Es
2
5
0

Analysis 9 - radius measurements Contributions of variables to D^2 analysis in order of importance

Distance from Neanderthal

Amud*	-ZMR	+SSR	-VRR	-EKR	-NAR	+PRR
Skhūl	+NAR	+EKR	+AVR	+ZOR	+SSR	-VRR
Saccopastore*	-ZMR	+EKR	+SSR	+NAR	-AVR	+PRR
Upper Palaeolithic	+AVR	+NAR	+PRR	-VRR	+EKR	+SSR
Mesolithic	+NAR	+PRR	+AVR	-VRR	+EKR	+SSR
Norse	+AVR	+EKR	+NAR	+PRR	+SSR	-VRR
Zulu	+AVR	+SSR	+NAR	+EKR	-VRR	
Tasmanian	+AVR	+NAR	+EKR	+PRR	-VRR	
Eskimo	+NAR	-ZMR	+AVR	+SSR	+PRR	-VRR
Cohuna	-ZMR	-VRR	+SSR	+EKR	+NAR	+AVR
Petralona	-ZMR	+ZOR	+AVR	+NAR	-PRR	-EKR
Djebel Irhoud*	+SSR	+ZOR	+AVR	+NAR	+VRR	
Hotu	+NAR	+AVR	+SSR	-VRR	+EKR	+PRR
Rhodesian*	+SSR	+ZOR	+EKR	-VRR		
Steinheim reconstruction	+NAR	+ZOR	+AVR	+SSR	+VRR	+PRR

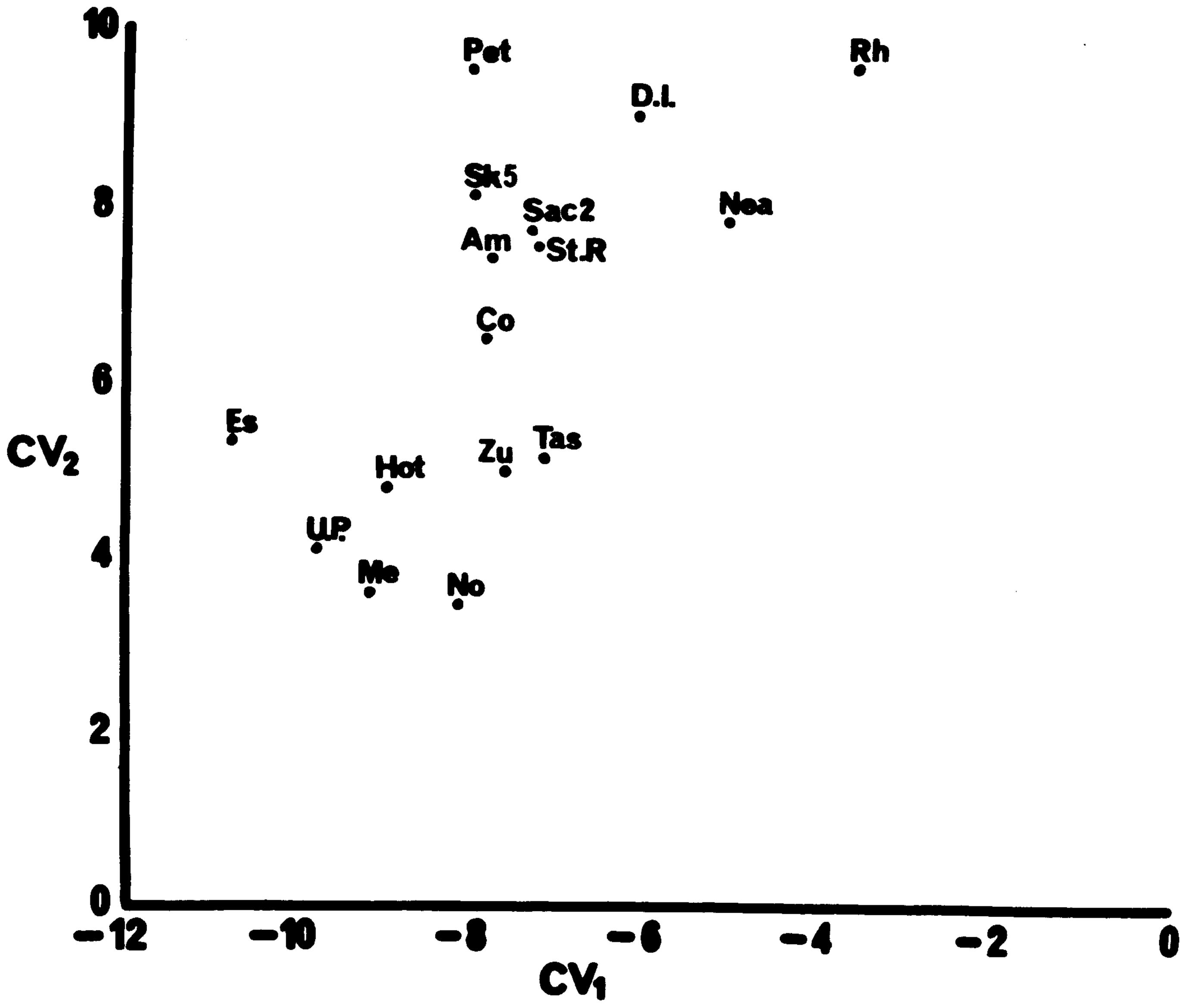
Analysis 9 - radius measurements (contd.)

Distance from Upper Palaeolithic

Neanderthal	-AVR	-NAR	-PRR	+VRR	-EKR	-SSR
Amud	-NAR	-AVR	-EKR	-PRR	+VRR	
Skhūl	+NAR	-PRR	+ZOR	+VRR	-AVR	-SSR
Saccopastore	-AVR	+VRR	-PRR	-NAR	-EKR	
Mesolithic*	+ZMR	+FMR	+NAR	+PRR	-VRR	
Norse	+FMR	+VRR	+ZMR	+AVR		
Zulu	+FMR	+ZMR	+SSR	+ZOR	+VRR	+AVR
Tasmanian	+ZOR	+VRR	+ZMR	+FMR	+AVR	
Eskimo	-EKR	-ZMR	+VRR	-PRR	+NAR	
Cohuna	-PRR	-AVR	-NAR	+FMR	-VRR	-ZMR
Petralona	-PRR	+VRR	-ZMR	-EKR	-SSR	-NAR
Djebel Irhoud	-PRR	+VRR	+ZOR	+ZMR	-NAR	-EKR
Hotu*	+ZMR	+ZOR	+NAR	+AVR	+VRR	+SSR
Rhodesian	-PRR	-AVR	+ZMR	+ZOR	+VRR	-NAR
Steinheim reconstruction	+VRR	+ZOR	+ZMR	+FMR		

Fig. 33

Analysis 9 (EAM - radii measurements). Plot of canonical variates 1 and 2 for fossil and recent material.


10
8
6
4
2
0
CV2
Pet
Rh
D.L
Sk5
Sac2
Nea
Am
St.R
Co
Es
Hot
Zu
Tas
U.P.
Me
No
−12
−10
−8
−6
−4
−2
0
CV1

Analysis 10 Face - 8 variables (Figs 34-36)

Variables used (8)

OBH, OBB, NLB, EKB, SOS, NAR, ZOR, EKR

Sample

Neanderthal M.C., L.Ch, Gi, Fe (4)

Middle-east Neanderthals Am (1)

Skhūl Sk.5 (1)

Saccopastore Sac 1, 2 (2)

Krapina Kr C (1)

Upper Palaeolithic Pr 3, Ob 1, 2, Br 3, Lau 1, Or, Ma, S.T.3, A.C. 1, 4, 6, Gri, Ch, Cr 1, 2, Ko, C.C., G.C. (18)

Mesolithic Hoh 1, 2, Kau, Af 9, 10, 29, 32, Te 1, 11, Taf 11, 17, Gra (12)

Modern populations No (110), Zu (102), Tas (86), Es (108)

Individual cases Co, Pet, D.I., Hot, Rh, St, St.R.

TABLE 10 Matrix of generalized distances (D^2)

Analysis 10 - Face

	Nea	Am	Sk.5	Sac 1, 2	Kr C	U.P.	Me	No	Zu	Tas	Es	Co	Pet	D.I.	Hot	Rh	St	St.R.
Nea																		
Am	N.S.																	
Sk 5	59.93	36.02																
Sac 1,2	14.49	N.S.	N.S.															
Kr C	N.S.	N.S.	34.06	N.S.														
U.P.	51.40	45.47	20.51	15.27	14.74													
Me	53.91	47.48	22.67	17.23	19.86	N.S.												
No	59.59	61.64	39.56	25.89	25.13	6.13	4.35											
Zu	49.68	47.25	24.66	16.34	24.52	7.69	4.42	4.50										
Tas	40.13	40.29	22.95	14.55	18.36	6.74	4.20	7.97	3.38									
Es	75.67	78.31	49.88	40.34	25.95	12.19	14.02	11.30	18.70	26.10								
Co	31.73	23.27*	N.S.	N.S.	16.68*	N.S.	N.S.	18.31	12.37	N.S.	38.72							
Pet	76.17	28.66	N.S.	27.05	47.01	55.02	61.37	86.10	71.64	68.00	96.33	36.4						
D.I.	22.23	N.S.	N.S.	N.S.	19.31*	44.58	47.31	61.99	43.97	39.06	78.95	26.05	N.S.					
Hot	93.30	76.52	36.55	44.98	34.54	N.S.	N.S,	12.74	21.44	18.41	17.99	20.19*	65.9	72.85				
Rh	15.91	N.S.	31.44	11.78*	N.S.	56.31	63.57	72.30	62.20	51.88	91.22	35.75	22.56*	N.S.	89.50			
St	25.14	18.48*	42.76	34.82	35.55	68.68	70.62	84.59	68.84	51.25	104.23	51.38	67.29	N.S.	97.10	26.57		
St.R.	26.61	N.S.	31.02	26.09	21.81*	45.66	47.76	63.10	49.90	39.90	65.91	41.3	56.53	N.S.	68.24	37.66	N.S.	

Fig. 34

Analysis 10 (face - 8 variables). Graphical representation of generalised distances (D^2) for fossil and recent material. Neanderthal and Eskimo as reference axes.

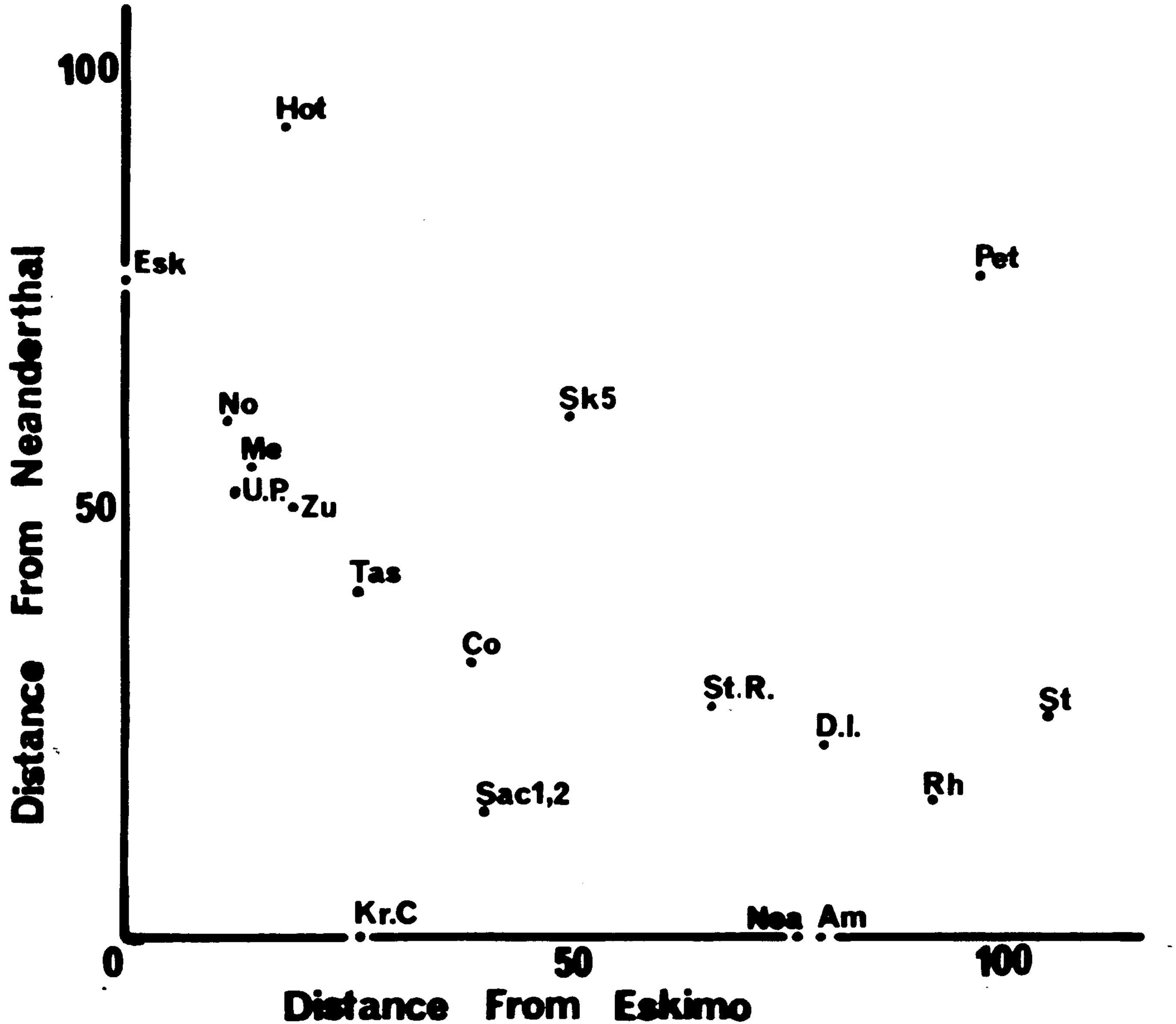

100
50
0
Distance From Neanderthal
Distance From Eskimo
50
100
Hot
Esk
Pet
No
Sk5
Me
U.P.
Zu
Tas
Co
St.R.
St
D.I.
Rh
Sac1,2
Kr.C
Nea Am

Fig. 35

Analysis 10 (face - 8 variables). Dendrogram from generalised distances (D^2) matrix.

St
St.R
Nea
Kr.C
Am
Rh
D.I.
Pet
Sk
Sac
Co
U.P.
Me
Hot
Es
Tas
Zu
No
5

Analysis 10 Face - 8 variables Contributions of variables to D^2 analysis in order of importance

Distance from Neanderthal

Amud*	-EKB	+OBB	-EKR	-NAR	-SOS	+OBH
Skhūl	+NAR	-EKB	+SOS	+OBH	+NLB	+OBB
Saccopastore	-EKB	+SOS	+NAR	+NLB	+OBB	+EKR
Krapina*	+NLB	+SOS	+ZOR	-EKR	+OBH	
Upper Palaeolithic	+SOS	+NLB	+OBH	+OBB	+NAR	+EKR
Mesolithic	+SOS	+NLB	+OBB	+OBH	+NAR	+EKR
Norse	+SOS	+NLB	+EKR	+OBB	+NAR	+OBH
Zulu	+SOS	+OBB	+NLB	+EKR	+NAR	+OBH
Tasmanian	+SOS	+NLB	+OBH	+OBB	+EKR	+NAR
Eskimo	+SOS	+NLB	+NAR	+OBB		
Cohuna	+OBH	+SOS	+NLB	+OBB	-EKB	+EKR
Petralona	-EKB	+NLB	+ZOR	+OBH	+NAR	-EKR
Djebel Irhoud	-EKB	+ZOR	+NAR	+OBB	+NLB	+SOS
Hotu	+NLB	+SOS	+OBH	+OBB	+ZOR	
Rhodesian	-EKB	+ZOR	+NLB	-SOS	+NAR	
Steinheim	+NAR	+ZOR	+OBB	+OBH	-SOS	
Steinheim reconstruction	+NAR	+OBB	-EKR	+ZOR	+NLB	+OBH

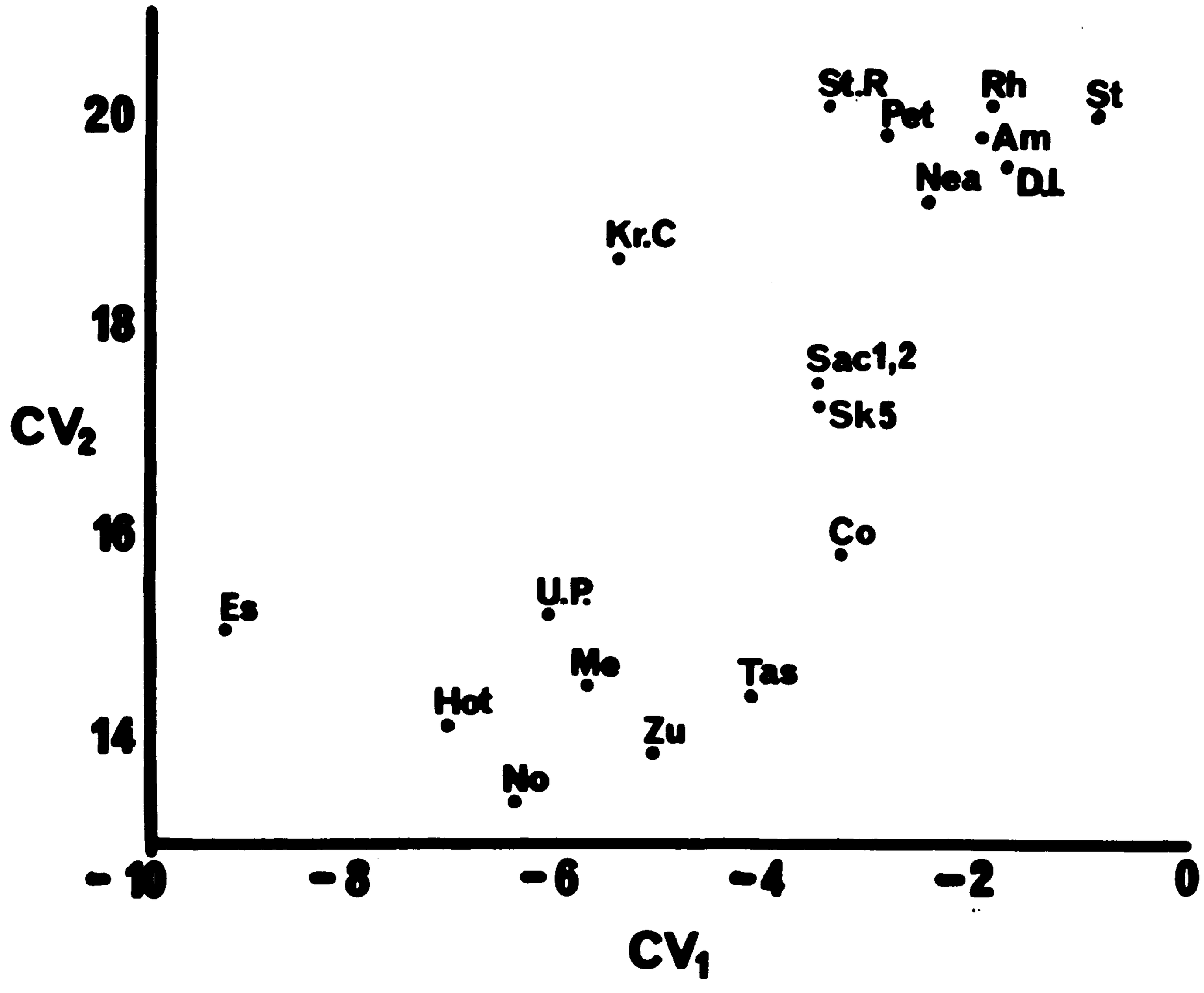
Analysis 10 Face - 8 variables (contd.)

Distance from Upper Palaeolithic

Neanderthal	-SOS	-NLB	-OBH	-OBB	-NAR	-EKR
Amud	-SOS	-NLB	-NAR	-OBH	-EKR	
Skhūl	-EKB	+NAR	-NLB	+ZOR	-SOS	
Saccopastore	-NLB	-SOS	-OBH	-EKB	-ZOR	
Krapina	-SOS	-OBB	-EKR	-OBH	-NAR	-NLB
Mesolithic*	+OBB	+EKR	+SOS	-NLB	+OBH	+EKB
Norse	+EKR	+EKB	-OBH	+SOS	+OBB	
Zulu	-NLB	+EKR	-OBH	+SOS	+OBB	+EKB
Tasmanian	-NLB	+EKR	+ZOR	+EKB	+OBH	
Eskimo	-OBH	+SOS	+EKB	-EKR	+NLB	-ZOR
Cohuna	-NLB	-SOS	-EKB	+OBH	-ZOR	-NAR
Petralona	-EKB	-SOS	-EKR	-NLB		
Djebel Irhoud	-SOS	-NLB	-EKB	-OBH	+ZOR	-EKR
Hotu*	+NLB	+ZOR	+OBB	+OBH	+SOS	
Rhodesian	-SOS	-OBH	-NLB	+ZOR	-OBB	-EKB
Steinheim	-SOS	-NLB	+ZOR	+NAR	+EKB	-OBH
Steinheim reconstruction	-SOS	-NLB	-EKR	+NAR	+EKB	-OBH

Fig. 36

Analysis 10 (face - 8 variables). Plot of canonical variates 1 and 2 for fossil and recent material.


St.R
Rh
St
Pet
Am
Nea
D.L
Kr.C
Sac1,2
Sk5
Co
U.P.
Es
Me
Tas
Hot
Zu
No
20
18
16
14
CV_2
-10
-8
-6
-4
-2
0
CV_1

Analysis 11 Face - 9 variables (Figs 37-39)

Variables used (9)

NPH, NLH, OBH, OBB, NLB, MAB, EKB, WMH, SOS

Sample

Neanderthal M.C., L.Ch, Gi, Fe (4)

Middle-east Neanderthals Am (1)

Skhūl Sk.5 (1)

Saccopastore Sac 1, 2 (2)

Upper Palaeolithic Pr 3, 4, Ob 1, 2, Br 3, D.V.3, Lau 1, Or, Ma, S.T.3, A.C. 1, 4, 6, Gri, Ch, Cr 1, 2, Ko, C.C., G.C. (20)

Mesolithic Hoh 1, 2, Kau, Of 25, Af 9, 10, 29, 32, Te 1, 11, Taf 11, 17, Gra (13)

Modern populations No (110), Zu (102), Tas (86), Es (108)

Individual cases Co, Pet, D.I., Hot, Rh, St, St.R.

TABLE 11 Matrix of generalised distances (D^2)

Analysis 11 - Face

	Nea	Am	Sk 5	Sac 1, 2	U.P.	Me	No	Zu	Tas	Es	Co	Pet	D.I.	Hot	Rh	St	St.R.
Nea																	
Am	N.S.																
Sk 5	51.53	29.26															
Sac 1,2	11.84	N.S.	N.S.														
U.P.	54.05	51.21	N.S.	18.78													
Me	58.91	54.30	N.S.	22.52	N.S.												
No	60.20	63.98	21.97	27.66	4.37	3.69											
Zu	57.95	54.73	12.19*	27.31	8.15	6.54	7.95										
Tas	52.72	55.09	12.42*	30.01	8.04	5.49	11.01	4.53									
Es	73.69	80.73	34.76	36.28	12.95	11.41	3.77	17.52	23.16								
Co	32.49	20.82*	N.S.	N.S.	N.S.	N.S.	20.94	14.89	9.48*	33.42							
Pet	75.92	25.4	30.68	28.53	67.56	61.17	87.92	84.12	89.40	92.52	26.63						
D.I.	36.64	N.S.	25.18*	20.78	49.01	50.94	61.24	39.52	41.22	76.14	18.01*	38.38					
Hot	96.25	83.8	N.S.	43.87	N.S.	N.S.	N.S.	16.19	15.39	13.57	N.S.	74.12	70.94				
Rh	17.18	N.S.	48.57	13.08*	59.74	66.06	71.09	65.57	65.83	76.88	24.7*	30.49	N.S.	89.00			
St	23.44	27.05	75.68	32.01	66.14	72.72	74.47	68.60	65.30	98.22	40.5	101.6	29.25	93.60	28.18		
St.R.	14.26*	N.S.	37.78	14.32*	35.99	31.78	38.19	34.14	26.97	53.15	N.S.	55.44	N.S.	52.7	17.67*	N.S.	

Fig. 37

Analysis 11 (face - 9 variables). Graphical representation of generalised distances (D^2) for fossil and recent material. Petralona and Eskimo as reference axes.

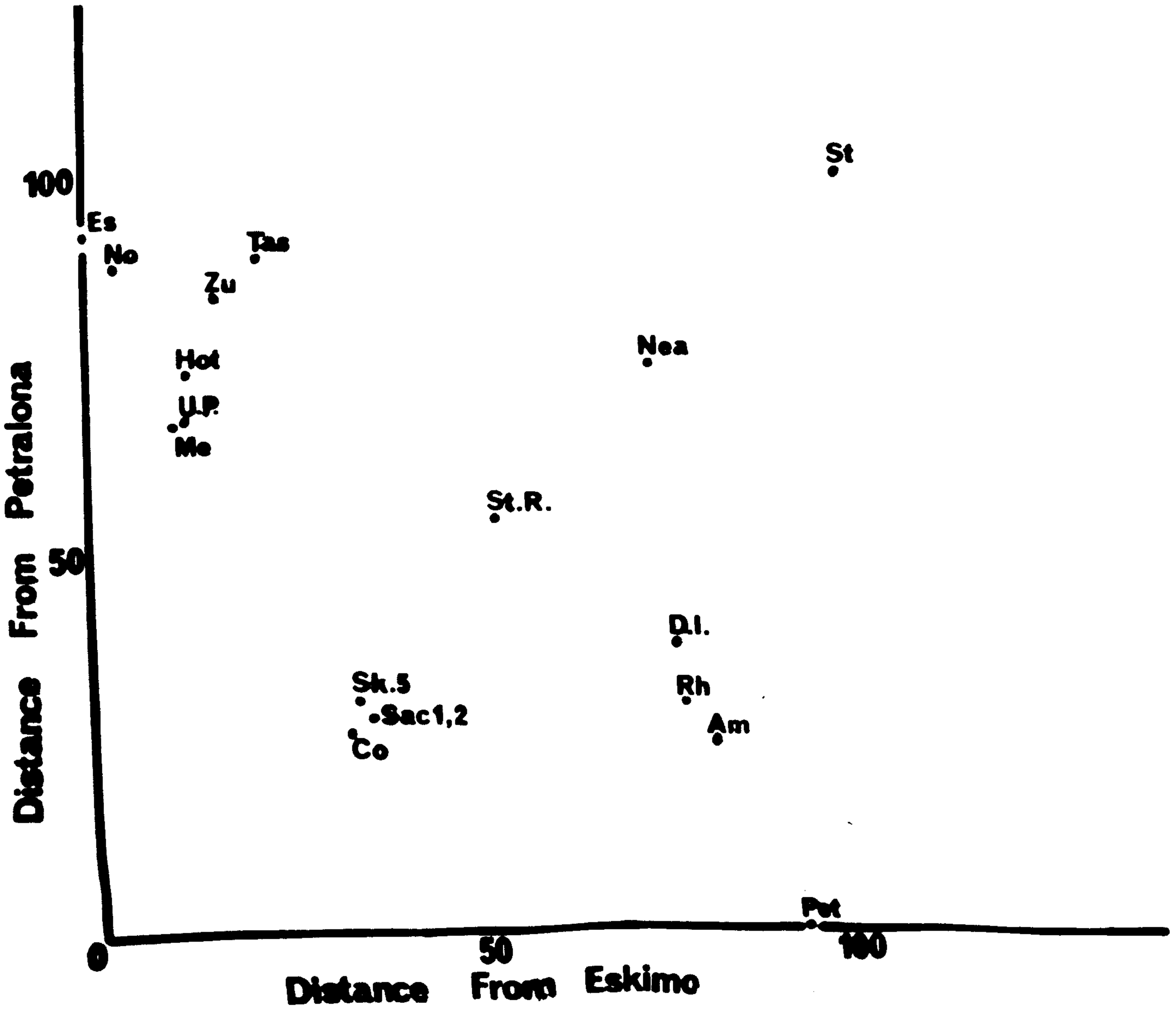
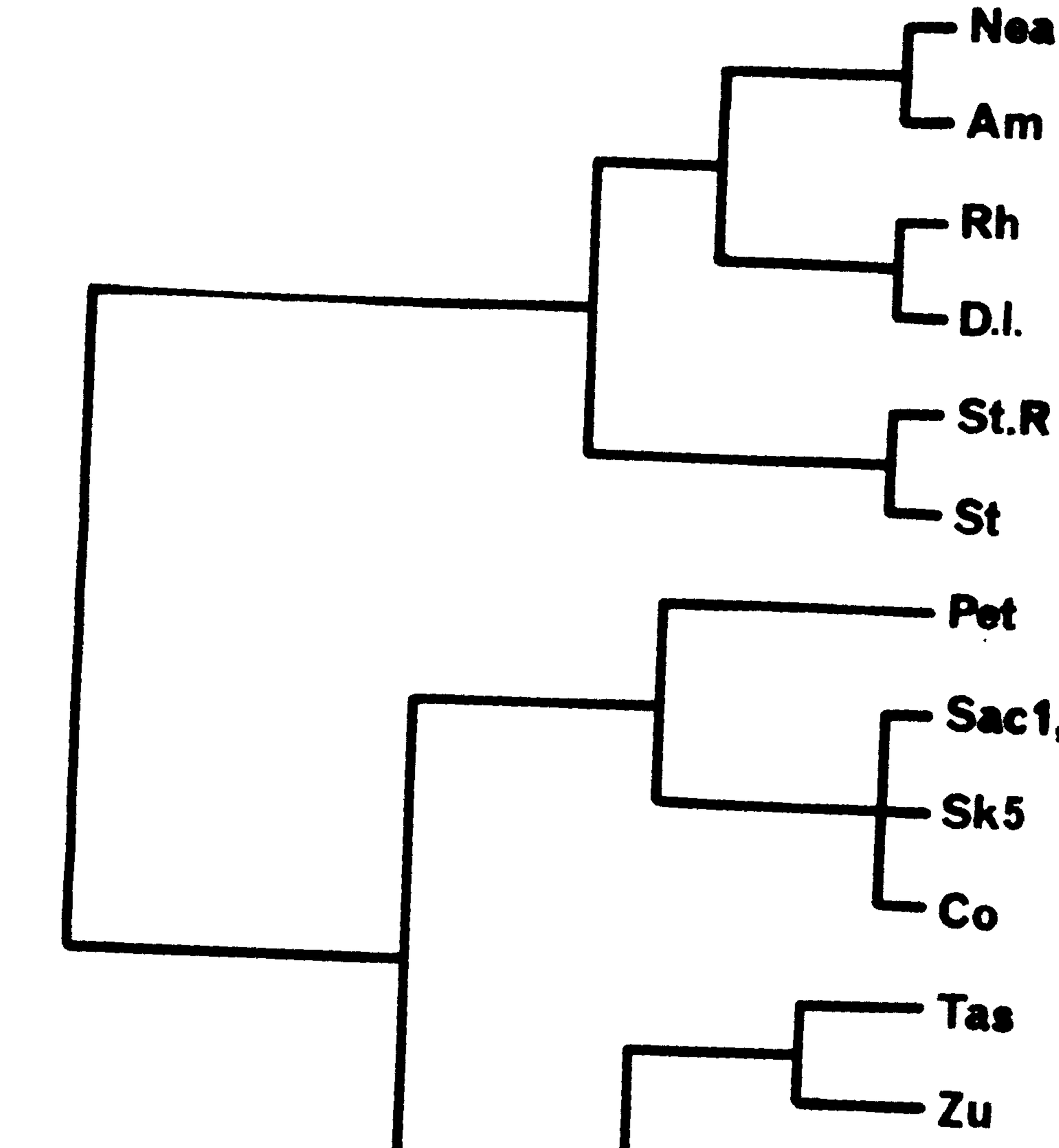

100
50
0
Distance From Petralona
Distance From Eskimo
50
100
Es
No
Tas
Zu
Hot
U.P.
Me
St.R.
St
Nea
D.I.
Sk.5
Sac1,2
Co
Rh
Am
Pet

Fig. 38

Analysis 11 (face - 9 variables). Dendrogram from generalised distances (D^2) matrix.


Nea
Am
Rh
D.l.
St.R
St
Pet
Sac1,2
Sk5
Co
Tas
Zu
U.P.
Me
Hot
No
Es
15
10
5
0

Analysis 11 Face - 9 variables Contributions to D^2 analysis in order of importance

Distance from Neanderthal

Amud*	+OBB	-EKB	-MAB	-NPH	-OBH	
Skhūl	+SOS	-EKB	+NLB	+OBH	+OBB	+NPH
Saccopastore	-EKB	+SOS	+NLB	+OBB	+OBH	-WMH
Upper Palaeolithic	+SOS	+NLB	+OBH	+OBB	+NPH	+WMH
Mesolithic	+SOS	+NLB	+OBB	+NPH	+OBH	+NLH
Norse	+SOS	+NLB	+NPH	+OBB	+NLH	+OBH
Zulu	+SOS	+OBB	+NLH	+NLB	+WMH	+NPH
Tasmanian	+SOS	+NPH	+NLB	+OBB	+NLH	+WMH
Eskimo	+SOS	+NLB	+NPH	+OBB	+NLH	
Cohuna	+OBH	+SOS	+NLH	+NLB	+OBB	-EKB
Petralona	-EKB	-MAB	+NLB	-NPH	+OBH	+SOS
Djebel Irhoud	+NLH	-EKB	+OBB	+WMH	-MAB	+NLB
Hotu	+NLB	+SOS	+OBB	+OBH	+NPH	+NLH
Rhodesian	-EKB	+NLH	-MAB	-NPH	+NLB	-OBH
Steinheim	+NLH	+OBB	+MAB	+OBH	-SOS	
Steinheim reconstruction	+OBB	+NLH	+EKB	+NPH	+NLB	+SOS

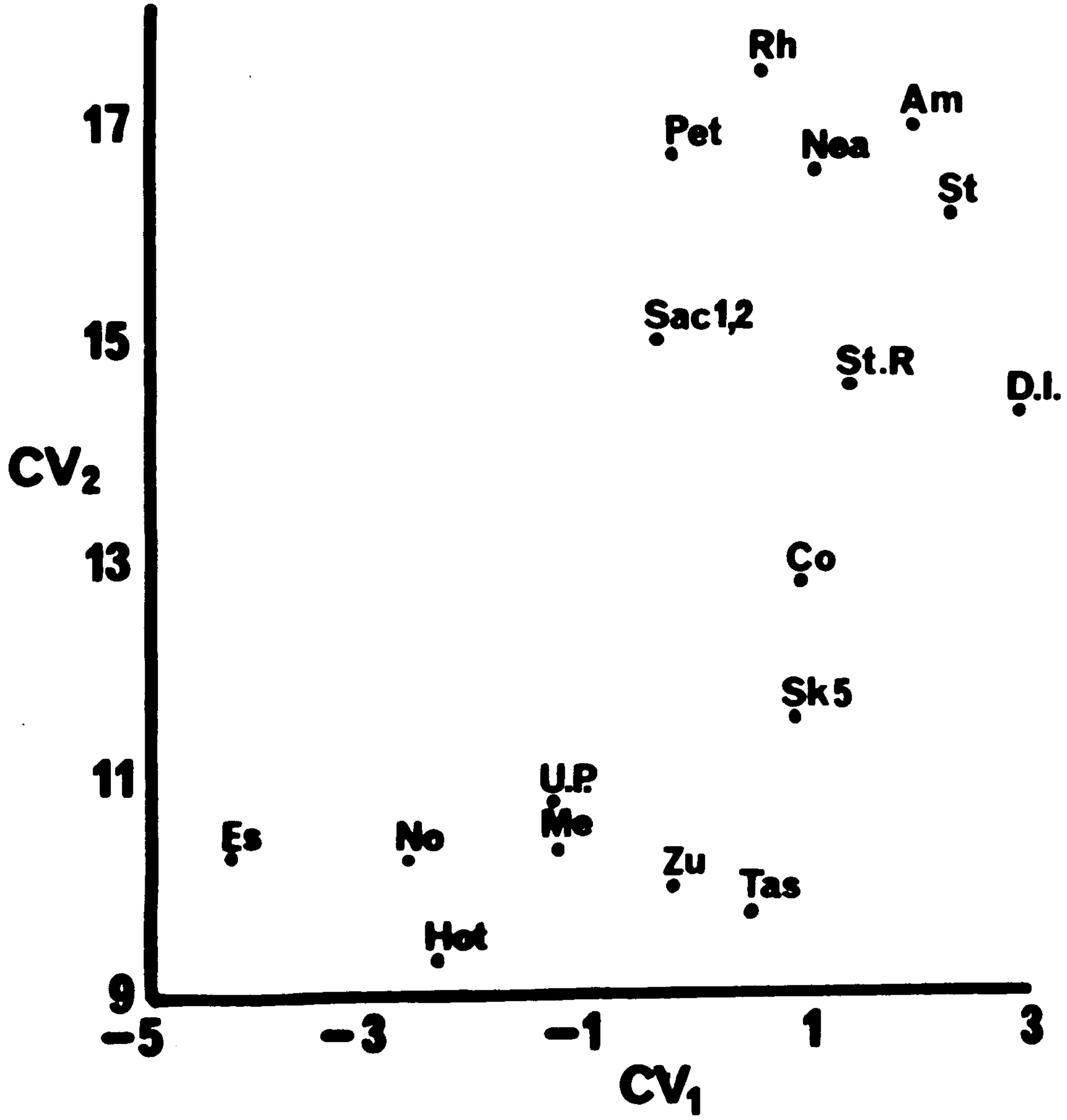
Analysis 11 Face - 9 Variables (contd.)

Distance from Upper Palaeolithic

Neanderthal	-SOS	-NLB	-OBH	-OBB	-NPH	-WMH
Amud	-SOS	-NLB	-NPH	-MAB	-OBH	-NLH
Skhūl*	-EKB	-NLB	-MAB	-NLH	-SOS	
Saccopastore	-NLB	-NPH	-SOS	-WMH	-OBH	
Mesolithic*	-MAB	+SOS	+OBB	-WMH	+NPH	+EKB
Norse	+EKB	-OBH	+SOS	-WMH	+NPH	+NLH
Zulu	-NLB	-OBH	+SOS	+NLH	+WMH	+OBB
Tasmanian	-NLB	+NPH	+EKB	+NLH	-MAB	+WMH
Eskimo	-OBH	+SOS	-WMH	+EKB	+NLB	-OBB
Cohuna*	-MAB	-NLB	-SOS	-NPH	+OBH	-WMH
Petralona	-EKB	-MAB	-NPH	-SOS	-WMH	-OBH
Djebel Irhoud	-SOS	-NLB	-OBH	-MAB	-EKB	-NPH
Hotu*	+NLB	+OBB	+OBH	+NLH	+SOS	-WMH
Rhodesian	-SOS	-NPH	-OBH	-MAB	-NLB	-OBB
Steinheim	-SOS	-NLB	-NPH	+NLH	-WMH	+EKB
Steinheim reconstruction	-SOS	-NLB	-MAB	-WMH	-OBH	+OBB

Fig. 39

Analysis 11 (face - 9 variables). Plot of canonical variates 1 and 2 for fossil and recent material.


Rh
Am
Pet
Nea
St
Sac1,2
St.R
D.I.
Co
Sk5
U.P.
Me
Es
No
Zu
Tas
Hot
17
15
13
11
9
CV2
−5
−3
−1
1
3
CV1

Analysis 12 Face - 11 variables (Figs 40-42)

Variables used (11)

OBH, OBB, JUB, NLB, ZMB, FMB, NAS, EKB, WMH, SOS, GLS

Sample

Neanderthal M.C., L.Ch, Gi, Fe (4)

Middle-east Neanderthals Am (1)

Skhūl Sk.5 (1)

Krapina Kr C (1)

Upper Palaeolithic Pr 3, 4, Ob 1, 2, Br 3, D.V.3, Lau 1, Or, Ma, S.T.3, A.C. 1, 4, 6, Gri, Ch, Cr 1, 2, Ko, C.C., G.C. (20)

Mesolithic Hoh 1, 2, Kau, Of 25, Af 9, 10, 29, 32, Te 1, 11, Taf 11, 17, Gra (13)

Modern populations No (110), Zu (99), Tas (86), Es (107)

Individual cases Co, Pet, D.I., Hot, Rh, St, St.R.

TABLE 12 Matrix of generalised distances (D^2)

Analysis 12 - Face

	Nea	Am	Sk.5	Kr C	U.P.	Me	No	Zu	Tas	Es	Co	Pet	D.I.	Hot	Rh	St	St.R.
Nea																	
Am	N.S.																
Sk 5	71.18	63.43															
Kr C	N.S.	19.68*	34.24														
U.P.	63.1	61.63	19.43	17.35													
Me	65.58	63.01	18.79	19.97	N.S.												
No	68.1	64.9	52.27	18.32	8.693	8.36											
Zu	65.53	65.26	37.25	24.24	10.78	10.37	8.23										
Tas	53.89	51.99	21.84	21.60	7.11	6.06	14.30	10.83									
Es	85.92	91.99	61.80	26.52	14.01	16.36	7.33	20.14	30.15								
Co	33.69	19.27*	N.S.	N.S.	20.26	21.51	37.51	39.04	17.31	56.16							
Pet	106.95	57.09	46.73	76.54	99.45	97.75	125.0	136.49	102.47	141.20	37.14						
D.I.	26.34	N.S.	N.S.	N.S.	35.38	39.77	58.54	42.36	33.93	73.68	21.41*	49.62					
Hot	97.55	88.40	25.13*	35.25	N.S.	N.S.	8.93*	18.39	14.38	15.13	24.02*	103.6	58.52				
Rh	29.99	23.73*	53.2	29.15	91.45	89.65	110.4	116.69	82.95	130.30	39.48	32.5	33.42	115.8			
St	64.67	82.80	62.57	68.98	112.95	108.95	146.7	141.39	94.17	166.50	67.45	89.2	44.54	131.5	41.6[illegible]		
St.R.	81.33	93.10	46.23	68.56	89.95	86.34	124.2	122.69	79.44	131.30	69.06	78.80	39.49	107.2	61.1[illegible]	N.S.	

Fig. 40

Analysis 12 (face - 11 variables). Graphical representation of generalised distances (D^2) for fossil and recent material. Neanderthal and Eskimo as reference axes.

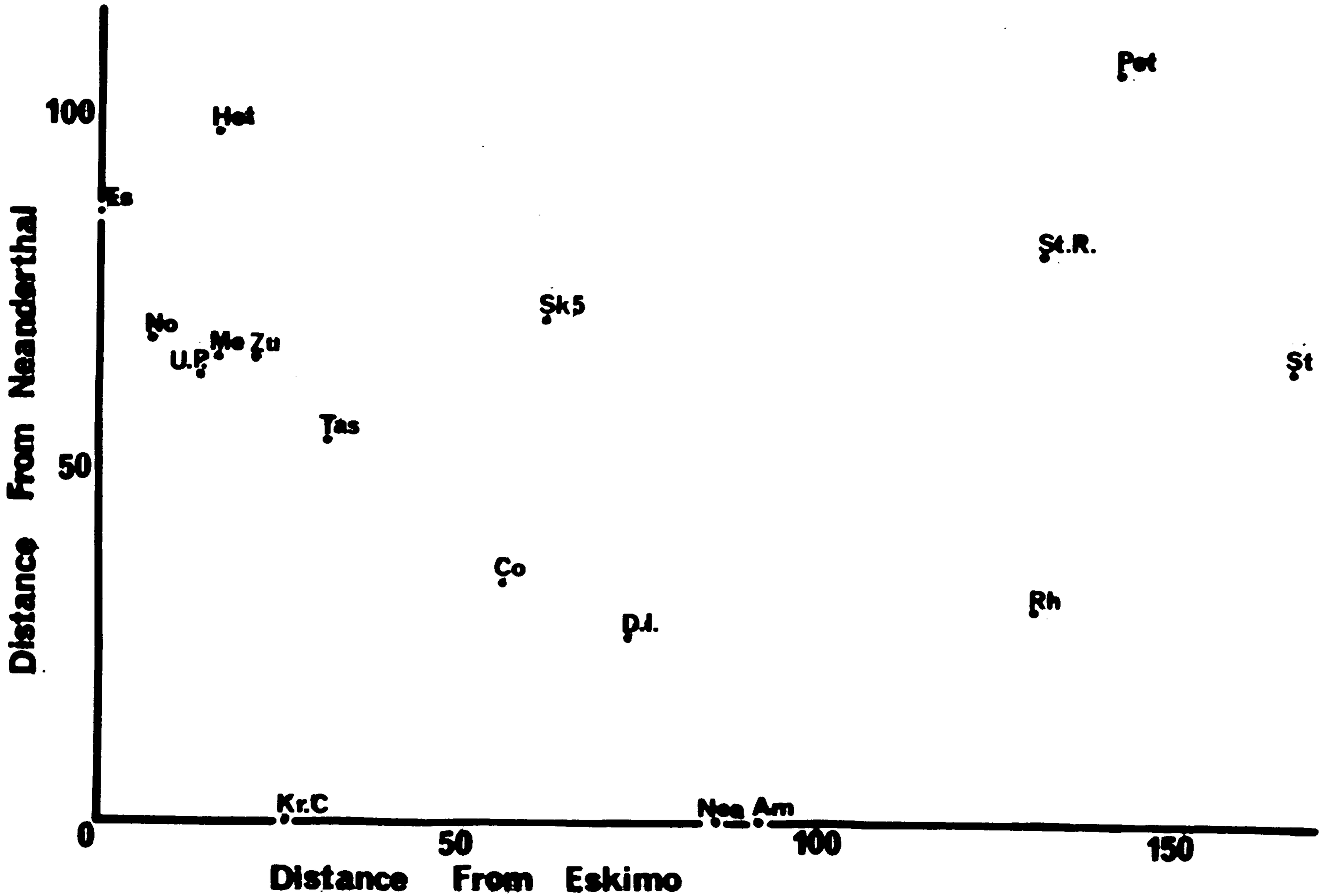
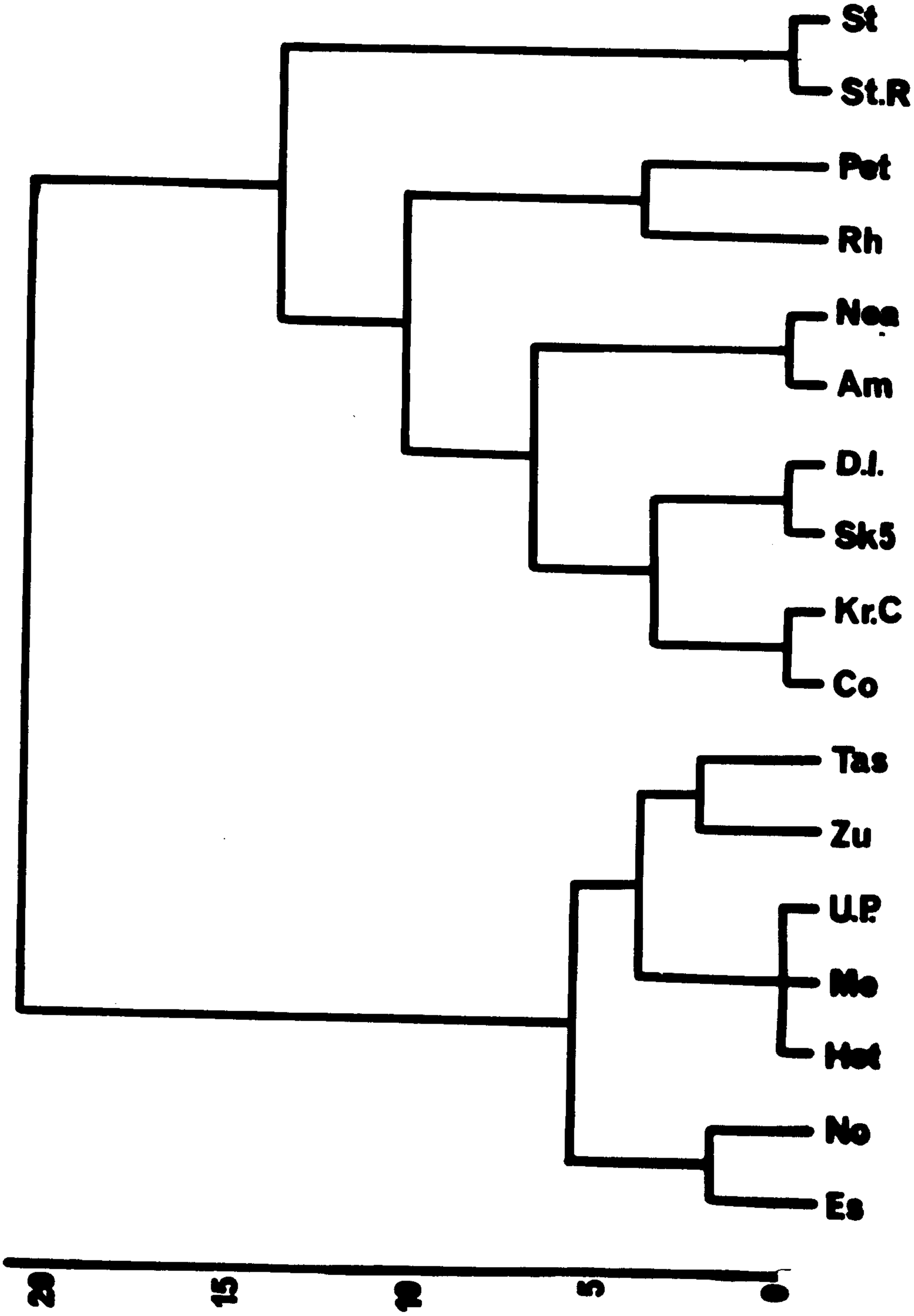

Distance From Neanderthal
100
50
0
Het
Es
No
U.P.
Me
Zu
Tas
Sk5
Pet
St.R.
St
Co
p.l.
Rh
Kr.C
Neg Am
50
100
150
Distance From Eskimo

Fig. 41

Analysis 12 (face - 11 variables). Dendrogram from generalised distances (D^2) matrix.


St
St.R
Pet
Rh
Neg
Am
D.I.
Sk5
Kr.C
Co
Tas
Zu
L.I.P.
Mo
Hot
No
Es
25
15
10
5
0

Analysis 12 Face - 11 variables Contributions of variables to D^2 analysis in order of importance

Distance from Neanderthal

Amud*	-EKB	+OBB	-NAS	-FMB	-JUB	-GLS
Skhūl	+NAS	+SOS	+OBH	-FMB	-EKB	+NLB
Krapina*	+NLB	+ZMB	+SOS	+GLS	+NAS	+OBH
Upper Palaeolithic	+SOS	+NLB	+OBH	+NAS	+OBB	+ZMB
Mesolithic	+SOS	+NLB	+OBH	+OBB	+ZMB	+NAS
Norse	+SOS	+NLB	+FMB	+ZMB	+OBB	+GLS
Zulu	+SOS	+GLS	+OBB	+ZMB	+NLB	+WMH
Tasmanian	+SOS	+ZMB	+OBH	+OBB	+WMH	+NLB
Eskimo	+SOS	+NLB	+FMB	+GLS	+NAS	+ZMB
Cohuna	+OBH	+SOS	+NLB	-EKB	+OBB	-GLS
Petralona	-EKB	-GLS	+NLB	-WMH	+ZMB	+SOS
Djebel Irhoud	-EKB	+NAS	+OBB	-FMB	+ZMB	+WMH
Hotu	+NLB	+SOS	+OBH	+OBB	+NAS	+ZMB
Rhodesian	-FMB	-GLS	+NLB	-OBH	-NAS	
Steinheim	+NAS	-GLS	+OBB	+EKB	+JUB	+ZMB
Steinheim reconstruction	+NAS	-GLS	+ZMB	+OBB	+EKB	+OBH

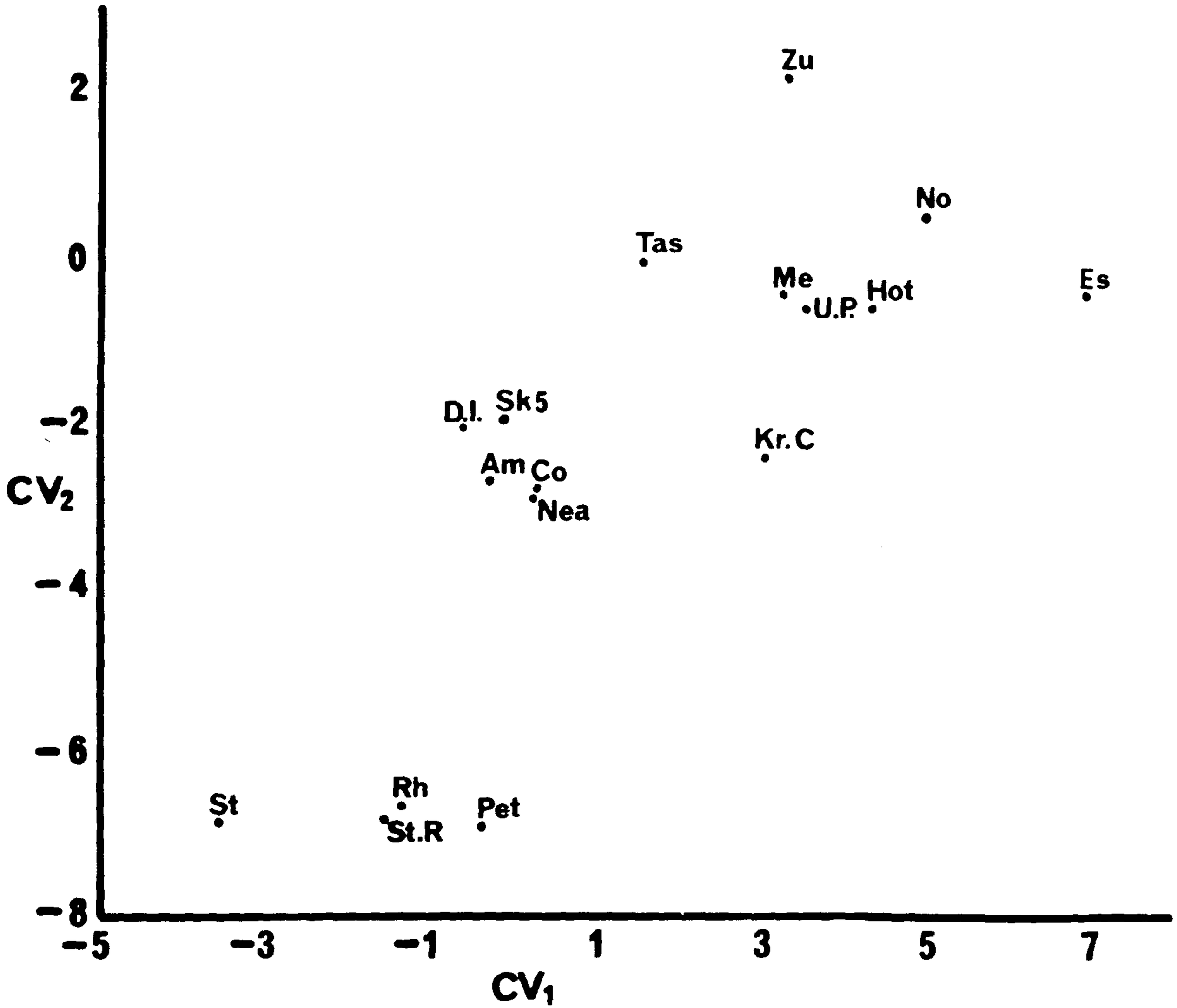
Analysis 12 Face - 11 variables (contd.)

Distance from Upper Palaeolithic

Neanderthal	-SOS	-NLB	-OBH	-NAS	-OBB	-ZMB
Amud	-NAS	-SOS	-NLB	-EKB	-OBH	-GLS
Skhūl	-FMB	-GLS	-NLB	+NAS		
Krapina	-FMB	-SOS	-OBH	-OBB	-WMH	-NAS
Mesolithic*	+EKB	+SOS	-WMH	-NAS	-NLB	-GLS
Norse	+FMB	-NAS	+GLS	-OBH	+ZMB	+SOS
Zulu	+GLS	-NLB	+SOS	-OBH	-NAS	+WMH
Tasmanian	-NLB	+ZMB	+EKB	+WMH	+JUB	-NAS
Eskimo	-OBH	+FMB	+GLS	+SOS	-WMH	+NLB
Cohuna	-EKB	-GLS	-NAS	-NLB	-WMH	-SOS
Petralona	-EKB	-GLS	-WMH	-FMB	-NAS	-SOS
Djebel Irhoud	-FMB	-SOS	-NLB	-OBH	-EKB	-GLS
Hotu*	+NLB	+OBB	+JUB	+OBH	+SOS	-WMH
Rhodesian	-FMB	-GLS	-SOS	-OBH	-NAS	-NLB
Steinheim	-GLS	-SOS	-FMB	-NLB	+JUB	+EKB
Steinheim reconstruction	-GLS	+NAS	-SOS	-NLB	-FMB	-WMH

Fig. 42

Analysis 12 (face - 11 variables). Plot of canonical variates 1 and 2 for fossil and recent material.


Zu
No
Tas
Me
U.P.
Hot
Es
D.I.
Sk5
Kr.C
Am
Co
Nea
St
Rh
St.R
Pet
2
0
−2
−4
−6
−8
−5
−3
−1
1
3
5
7
CV2
CV1

Analysis 13 Cranium - 25 variables (Figs 43-46)

Variables used (25)

GOL, NOL, XCB, XFB, ZYB, AUB, ASB, NPH, NLH,

OBH, OBB, JUB, NLB, MAB, MDH, MDB, ZMB, FMB,

NAS, EKB, SOS, GLS, VRR, FMR, ZMR

Sample

Neanderthal L.Ch, Fe (2)

Middle-east Neanderthals Am (1)

Skhūl Sk 5 (1)

Upper Palaeolithic Pr 3, 4, Ob 1, Lau 1, Or, S.T.3,

A.C. 1, 6, Ch, Cr 1, Ko, C.C., G.C. (13)

Mesolithic Hoh 1, 2, Kau, Af 9, 10, 29, 32, Te

1, 11, Taf 11, 17, Gra (12)

Modern populations No (110), Zu (99), Tas (86), Es (107)

Individual cases Pet, D.I., Hot, Rh, St.R.

TABLE 13 Matrix of generalised distances (D^2)

Analysis 13 Cranium

Nea														
Am	21.97*													
Sk 5	146.5	114												
U.P.	134.4	109.5	43.13											
Me	147.5	103.4	47.5	4.79										
No	148.6	100.1	99.07	25.40	18.33									
Zu	168.4	112.1	86.65	32.30	21.03	14.97								
Tas	151.4	103.0	50.73	30.67	17.30	23.39	19.52							
Es	196.9	157.6	105.9	31.83	36.15	26.53	40.04	42.75						
Pet	157.7	122.4	132.6	236.0	241.8	265.0	284.1	225.4	286.3					
D.I.	66.9	66.1	42.0	99.58	109.9	132.1	119.7	87.41	156.5	89.6				
Hot	170.6	125.6	74.0	N.S.	N.S.	14.08*	18.65*	26.66	31.28	263.5	130.2			
Rh	91.7	60.4	80.4	163.0	165.5	203.3	203.2	167.9	257.1	116.5	76.1	202.7		
St.R.	186	134.4	48.44	139.8	132.6	190.5	172.9	126.0	209.6	209.0	103.1	169.6	69.20	
	Nea	Am	Sk 5	U.P.	Me	No	Zu	Tas	Es	Pet	D.I.	Hot	Rh	St.R.

Fig. 43

Analysis 13 (skull - 25 variables). Graphical representation of generalised distances (D^2) for fossil and recent material. Petralona and Eskimo as reference axes.

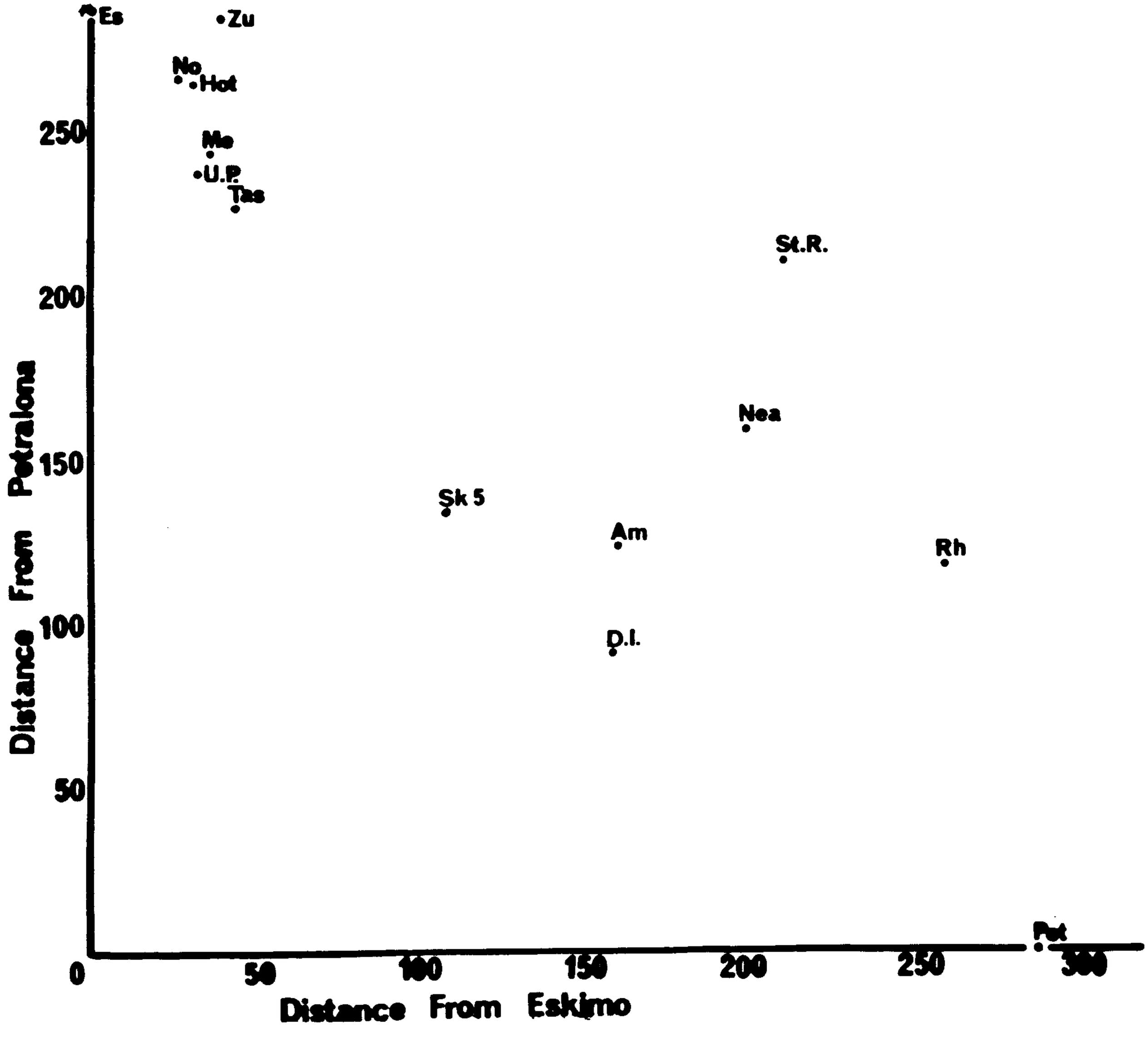

Es
Zu
No
Hot
Me
U.P.
Tas
St.R.
Nea
Sk 5
Am
Rh
D.I.
Pet
250
200
150
100
50
0
50
100
150
200
250
300
Distance From Petralona
Distance From Eskimo

Fig. 44

Analysis 13 (skull - 25 variables). Graphical representation of generalised distances (D^2) for fossil and recent material. Neanderthal and Eskimo as reference axes.

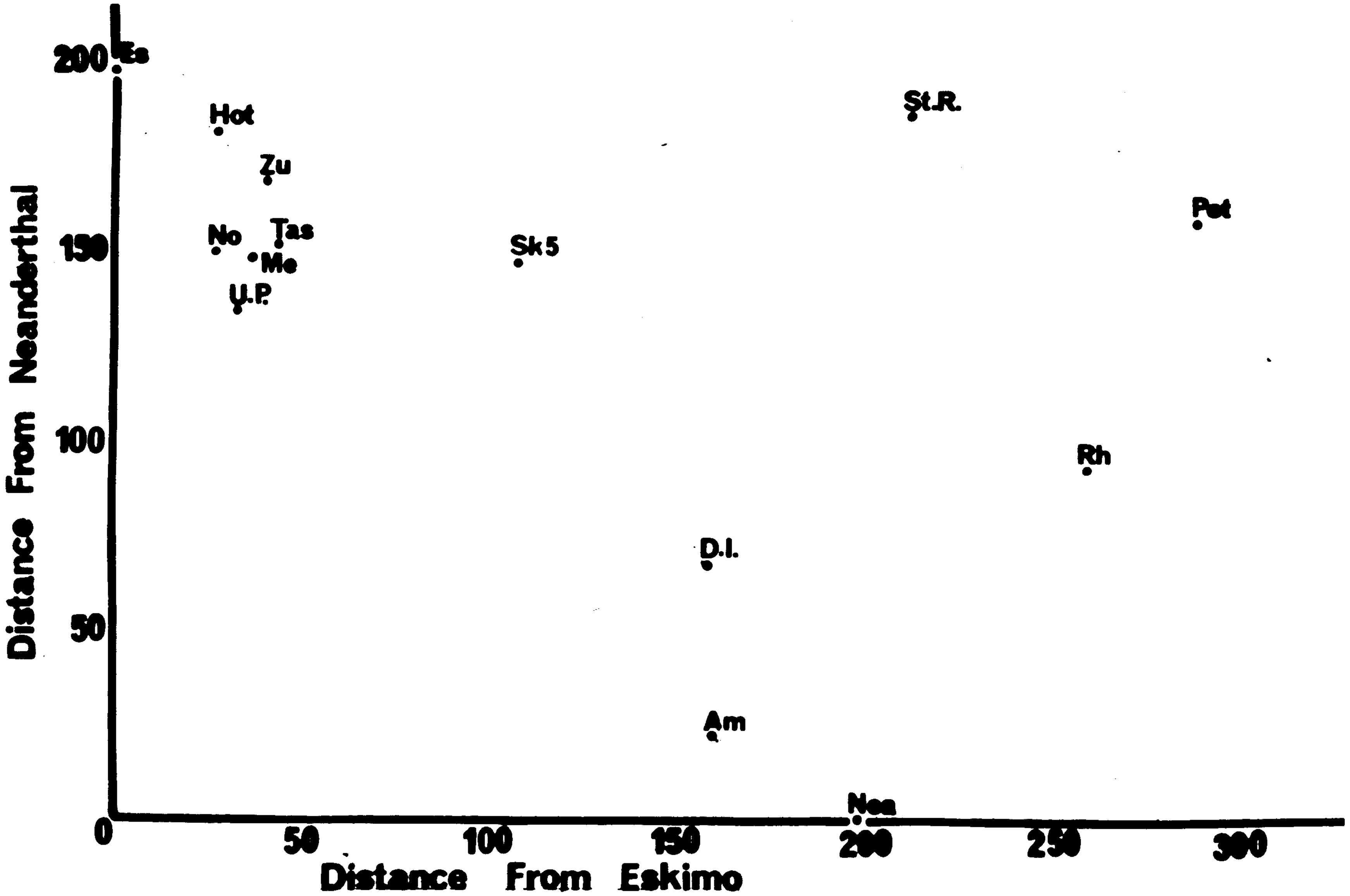
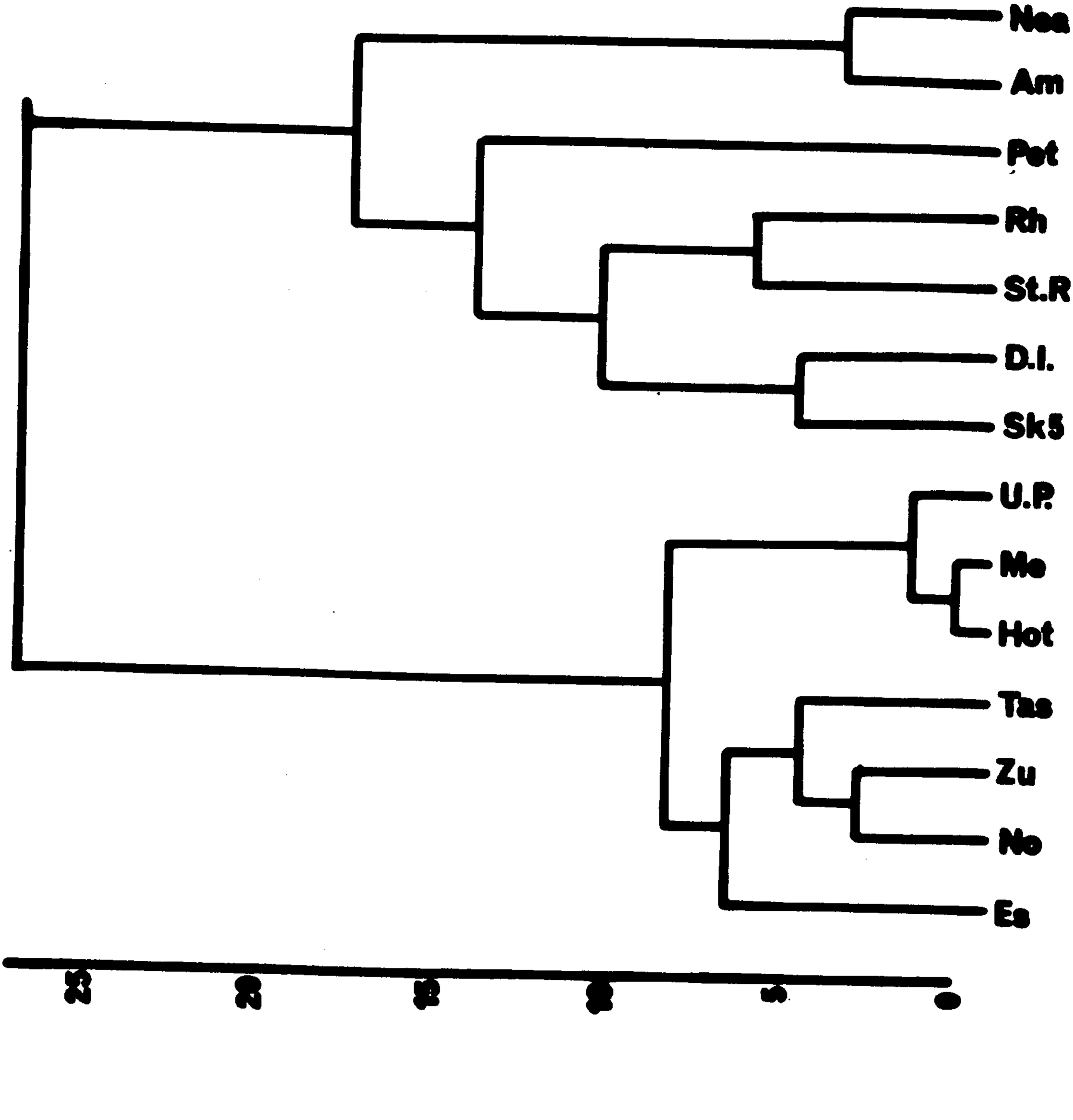

Distance From Neanderthal
200
150
100
50
0
50
100
150
200
250
300
Distance From Eskimo
Es
Hot
Zu
No
Tas
Me
U.P.
Sk5
St.R.
Pet
Rh
D.I.
Am
Nea

Fig. 45

Analysis 13 (skull - 25 variables). Dendrogram from generalised distances (D^2) matrix.


Nea
Am
Pet
Rh
St.R
D.I.
Sk5
U.P.
Me
Hot
Tas
Zu
No
Es

Analysis 13 Cranium - 25 variables Contributions of variables to D^2 analysis in order of importance

Distance from Neanderthal

Amud*	-MDH	+OBB	-ASB	-JUB	+ZYB	-VRR
Skhūl	+NOL	+SOS	+NAS	+NPH	+ZMB	+OBB
Upper Palaeolithic	+NOL	+SOS	+XCB	+NLB	+NPH	+ZMB
Mesolithic	+NOL	+SOS	+NPH	+ZMB	+XCB	-VRR
Norse	+NOL	+SOS	-MDH	+ZMB	+NPH	+GLS
Zulu	+NOL	+SOS	+GLS	+ZMB	-MDH	+NPH
Tasmanian	+NOL	+SOS	+NPH	+ZMB	-MDH	+XCB
Eskimo	+NOL	+SOS	+XCB	+NLB	+NPH	+GLS
Petralona	-EKB	-GLS	-AUB	+NOL	-MAB	+OBB
Djebel Irhoud	+NOL	+NLH	+OBB	+NAS	+ZMB	-FMB
Hotu	+SOS	+NLB	+NOL	+XCB	+NPH	+OBB
Rhodesian	-FMB	+NOL	-JUB	-GLS	+ZYB	+XCB
Steinheim reconstruction	+NOL	+NAS	+ZYB	+XCB	+ZMB	+EKB

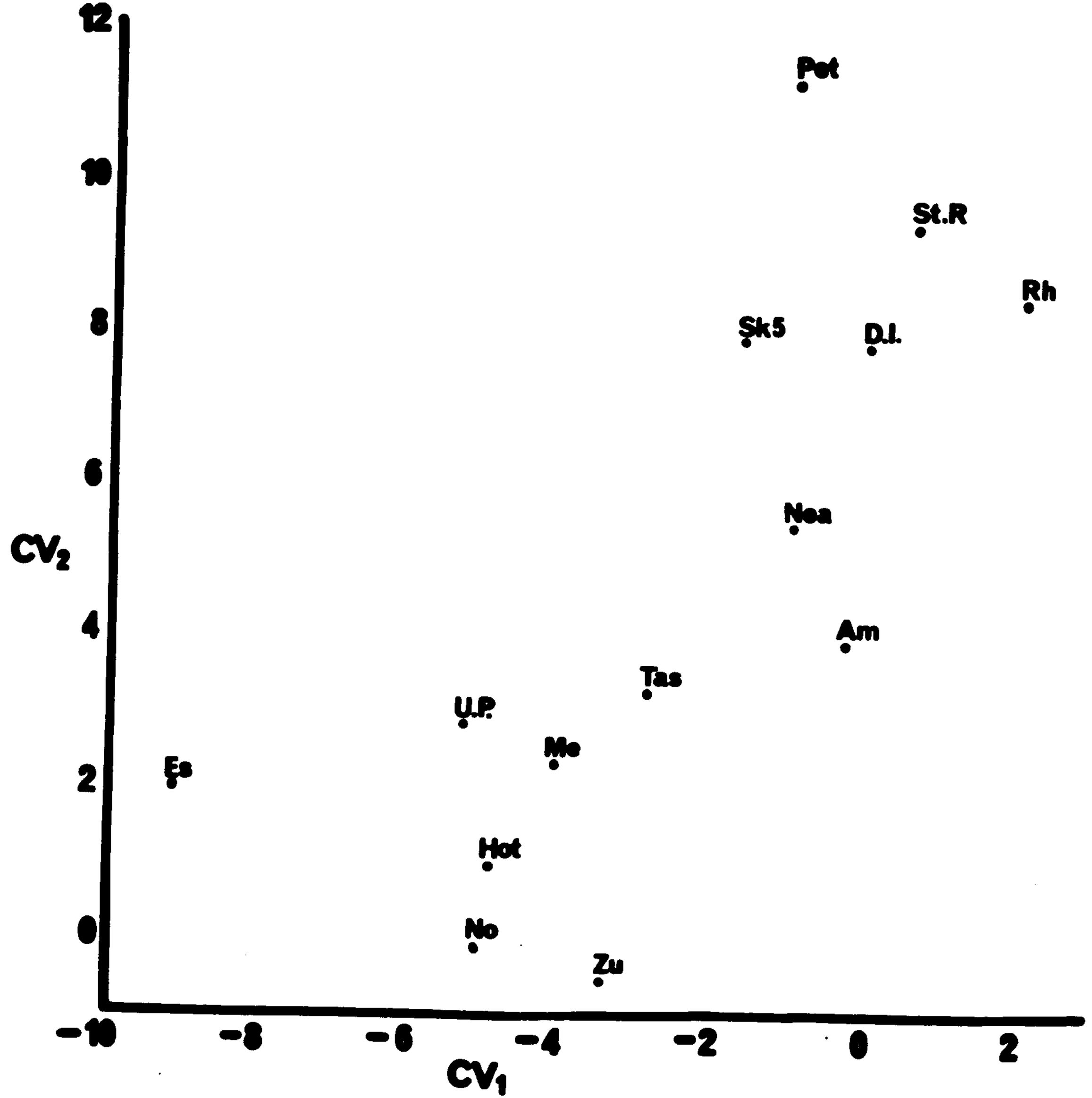
Analysis 13 Cranium - 25 variables (contd.)

Distance from Upper Palaeolithic

Neanderthal	-NOL	-SOS	-XCB	-NLB	-NPH	-ZMB
Amud	-NOL	-SOS	-ASB	-NAS	-NPH	-GLS
Skhūl	-FMB	+NOL	-NLH	-MAB	-NLB	-GLS
Mesolithic	+GOL	-MAB	+EKB	+NPH	+OBB	+ZMR
Norse	+FMB	+MDB	-MDH	+GOL	+FMR	+VRR
Zulu	+MDB	+AUB	-MAL	+GLS	-NLB	+FMR
Tasmanian	+NOL	+MDB	+NPH	+XFB	-NLB	+ZMB
Eskimo	+NOL	+FMB	+MDB	-OBH	+SOS	-ZMR
Petralona	-EKB	-GLS	-AUB	-MAB	-NPH	+MDB
Djebel Irhoud	-FMB	-ZYB	-NLB	-SOS	+VRR	+MDB
Hotu*	+GOL	+NLB	+AUB	+OBB	+JUB	+OBH
Rhodesian	-FMB	-GLS	-NPH	-SOS	-MAB	-OBH
Steinheim reconstruction	+NOL	-GLS	+ZYB	-SOS	+NAS	-NLB

Fig. 46

Analysis 13 (skull - 25 variables). Plot of canonical variates 1 and 2 for fossil and recent material.


12
10
8
6
4
2
0
−10
−8
−6
−4
−2
0
2
CV2
CV1
Pet
St.R
Rh
Sk5
D.I.
Nea
Am
Tas
U.P.
Me
Es
Hot
No
Zu

Analysis 14 Cranium - 25 variables (Figs 47-50)

Variables used (25)

GOL, XCB, AUB, ASB, NPH, NLH, OBH, OBB, NLB, MAB, EKB, WMH, SOS, FRC, FRS, FRF, PAC, PAS, VRR, NAR, SSR, PRR, ZOR, EKR, AVR

Sample

Neanderthal M.C., L.Ch, Gi, Fe (4)

Middle-east Neanderthals Am (1)

Skhūl Sk.5 (1)

Saccopastore Sac 1 (1)

Upper Palaeolithic Pr 3, Ob 1, 2, Br 3, Lau 1, Or, S.T.3, A.C. 1, 4, 6, Gri, Ch, Cr 1, 2, Ko, C.C., G.C. (17)

Mesolithic Hoh 1, 2, Kau, Af 9, 10, 29, 32, Te 1, 11, Taf 11, 17, Gra (12)

Modern populations No (110), Zu (102), Tas (86), Es (108)

Individual cases Co, Pet, D.I., Hot, Rh, St, St.R.

TABLE 14 Matrix of generalised distances (D^2)

Analysis 14 Cranium

	Nea	Am	Sk.5	Sac 1	U.P.	Me	No	Zu	Tas	Es	Co	Pet	D.I.	Hot	Rh	St	St.R.
Nea																	
Am	N.S.																
Sk 5	82.35	53.00															
Sac 1	N.S.	N.S.	40.31														
U.P.	127.38	97.73	41.55	95.33													
Me	126.87	99.52	42.18	84.22	2.50												
No	103.52	100.27	58.62	69.50	14.27	14.69											
Zu	121.51	97.35	45.38	87.35	20.28	21.01	20.26										
Tas	96.16	93.31	36.55	68.70	18.09	16.79	16.59	10,67									
Es	147.62	140.86	74.23	103.67	18.63	23.14	20.69	36.48	38.04								
Co	158.15	126.30	65.10	130.80	104.03	84.82	118.97	113.26	104.31	125.07							
Pet	107.75	71.9	67.70	84.40	187.13	186.32	188.97	204.56	184.31	216.37	172.00						
D.I.	57.99	35.99*	46.32	26.81*	121.73	117.12	126.97	108.56	93.91	154.17	143.20	52.50					
Hot	145.55	106.70	34.68*	100.50	N.S.	N.S.	N.S.	18.89*	14.96*	17.73*	56.00	172.80	124.1				
Rh	44.14	N.S.	59.00	42.16	151.03	151.42	143.67	141.46	129.41	176.57	96.20	46.22	N.S.	138.90			
St	64.73	40.18	123.80	63.1	201.43	205.62	193.77	198.46	181.71	242.07	209.20	120.40	80.6	190.20	50.50		
St.R.	61.32	35.49*	64.50	N.S.	114.23	112.12	123.77	113.76	97.11	136.67	172.30	96.50	35.14*	112.90	73.40	26.62*	

Fig. 47

Analysis 14 (skull - 25 variables). Graphical representation of generalised distances (D^2) for fossil and recent material. Neanderthal and Upper Palaeolithic as reference axes.

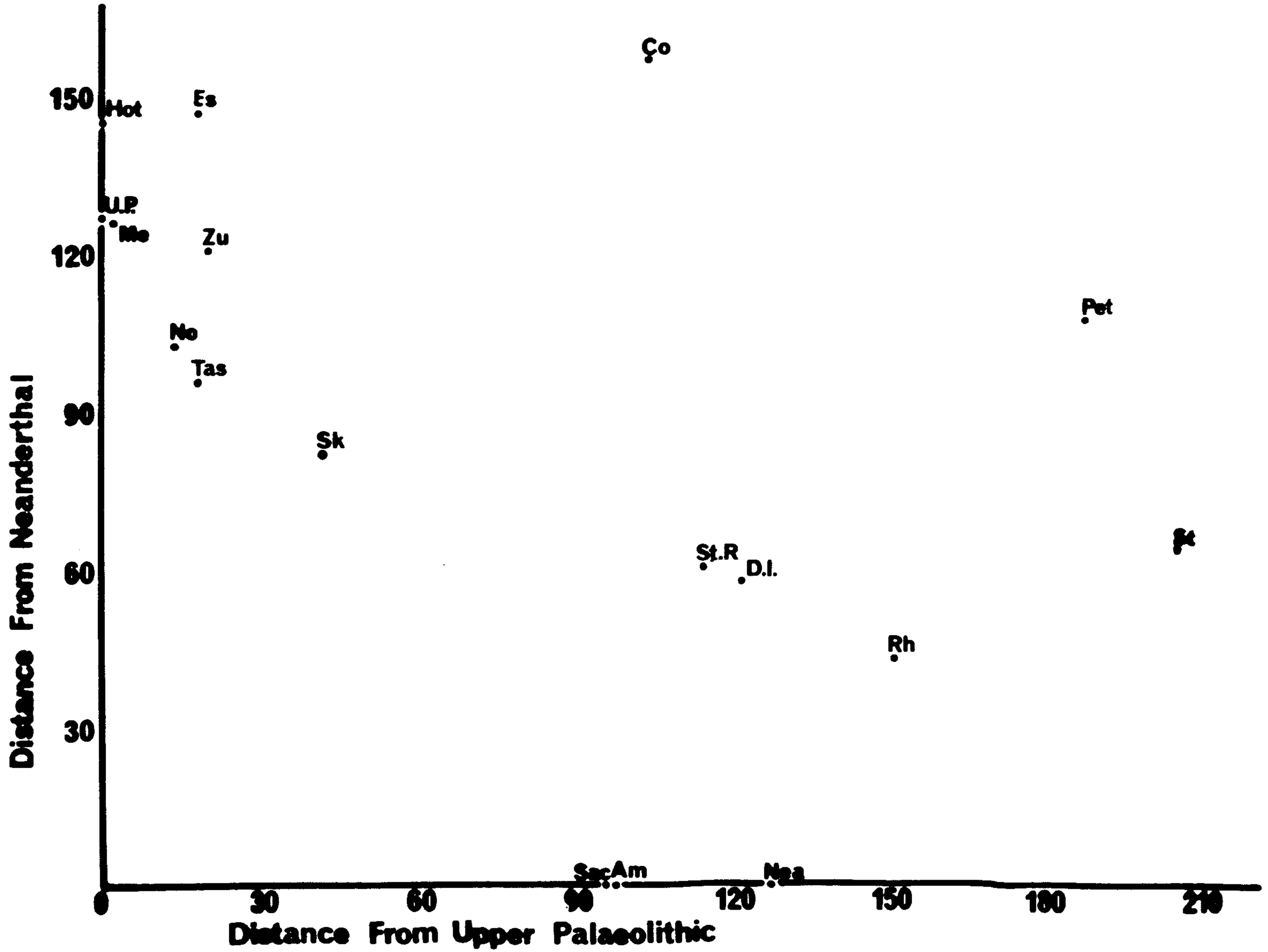

Distance From Neanderthal
Distance From Upper Palaeolithic
0
30
60
90
120
150
180
210
Hot
Es
U.P.
Me
Zu
No
Tas
Sk
Ço
Pet
St.R
D.I.
Rh
SacAm
Nea

Fig. 48

Analysis 14 (skull - 25 variables). Graphical representation of D ($= \sqrt{D^2}$) for the same reference axes as figure 47.

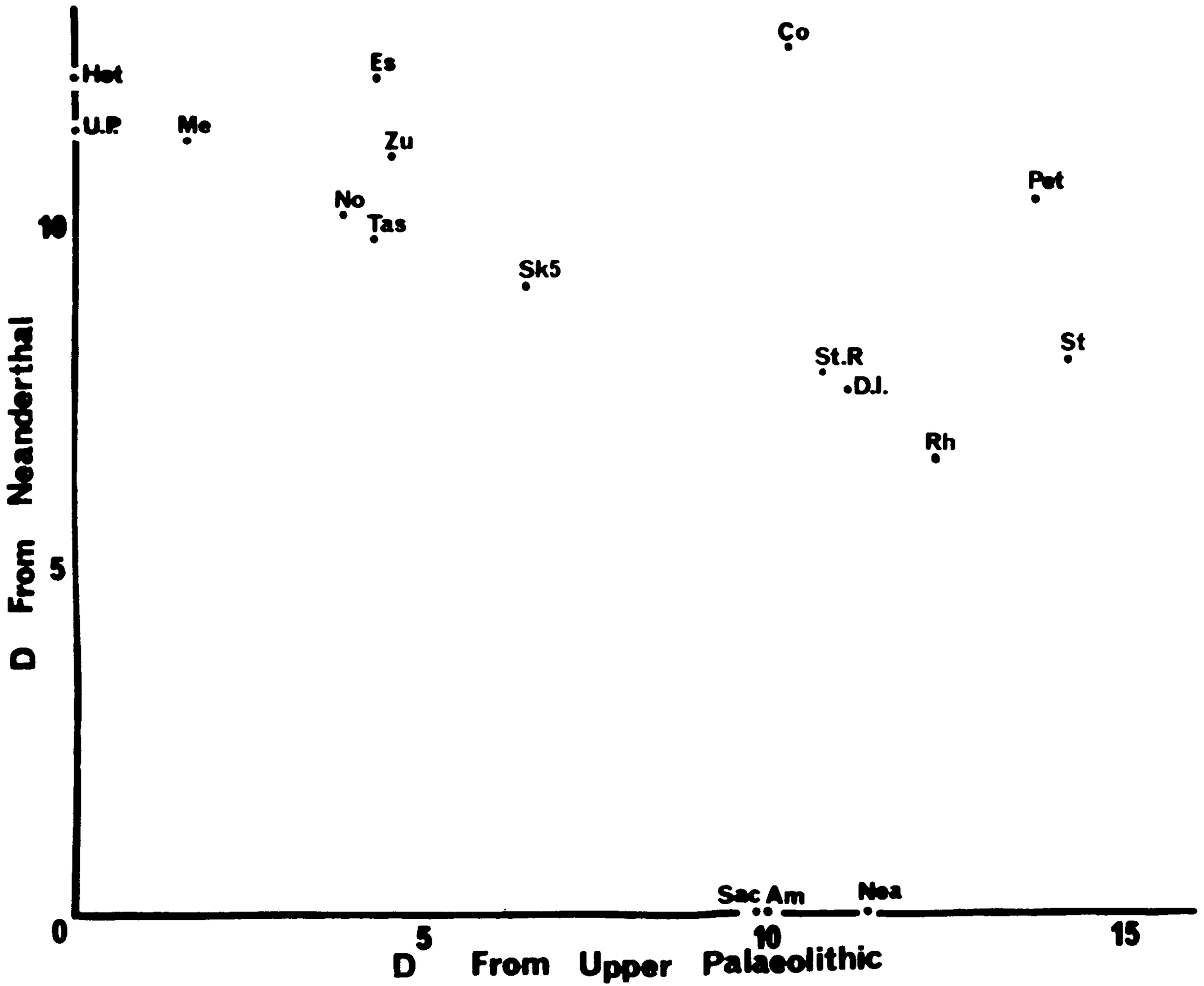
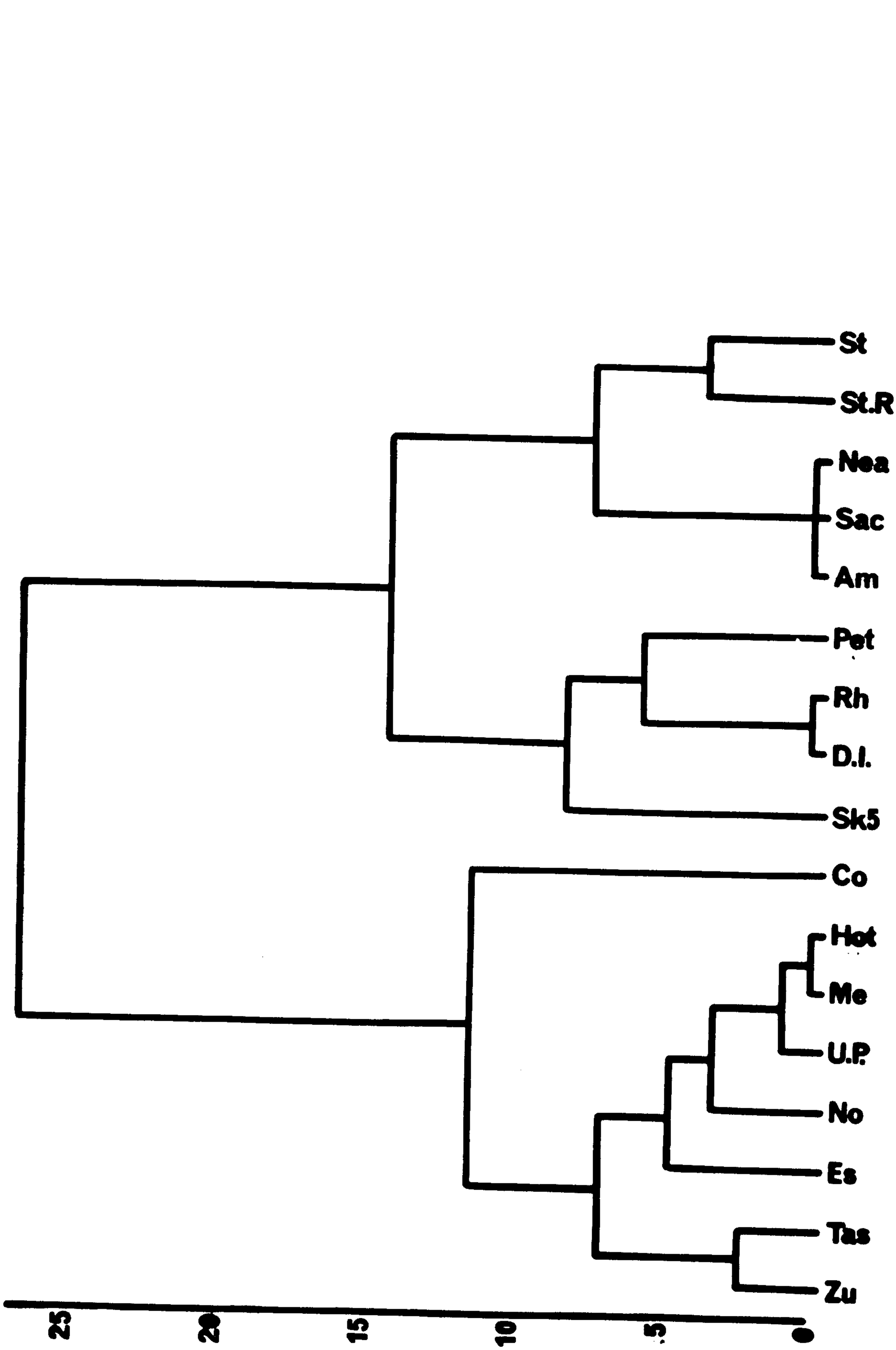

Hot
U.P.
Me
Es
Zu
No
Tas
Sk5
Co
Pet
St
St.R
D.J.
Rh
Sac
Am
Nea
10
5
0
5
10
15
D From Neanderthal
D From Upper Palaeolithic

Fig. 49

Analysis 14 (skull - 25 variables). Dendrogram from generalised distances (D^2) matrix.


St
St.R
Nea
Sac
Am
Pet
Rh
D.I.
Sk5
Co
Hot
Me
U.P.
No
Es
Tas
Zu
25
20
15
10
5
0

Analysis 14 Cranium - 25 variables Contributions of variables to D^2 analysis in order of importance

Distance from Neanderthal

Amud*	-EKB	+OBB	-ASB	+SSR	-MAB	-VRR
Skhūl	+NAR	-EKB	+XCB	+SOS	+NPH	-PAC
Saccopastore*	+GOL	+NAR	+SOS	+AUB	+FRC	+PAS
Upper Palaeolithic	+SOS	+XCB	+NLB	+PRR	-VRR	-PAC
Mesolithic	+SOS	+PRR	+NLB	+XCB	-VRR	-PAC
Norse	+SOS	+NLB	+PRR	+XCB	+EKR	+GOL
Zulu	+SOS	+XCB	+SSR	+GOL	+FRF	+OBB
Tasmanian	+SOS	+XCB	+NPH	+GOL	+NLB	+WMH
Eskimo	+SOS	+XCB	+NLB	+GOL	+PRR	+EKB
Cohuna	+XCB	-FRF	-VRR	+SSR	+NPH	+OBH
Petralona	-EKB	-MAB	-AUB	-NPH	+NLB	-FRF
Djebel Irhoud	+NLH	-EKB	-PAC	+PAS	+OBB	+NAR
Hotu	+NLB	+SOS	+XCB	+PRR	+OBH	+OBB
Rhodesian	-EKB	+ZOR	+SSR	+XCB	-FRC	-MAB
Steinheim	+NAR	+NLH	+PRR	+AUB	+ZOR	+XCB
Steinheim reconstruction	+FRC	+XCB	+NAR	+AVR	+AUB	+NLH

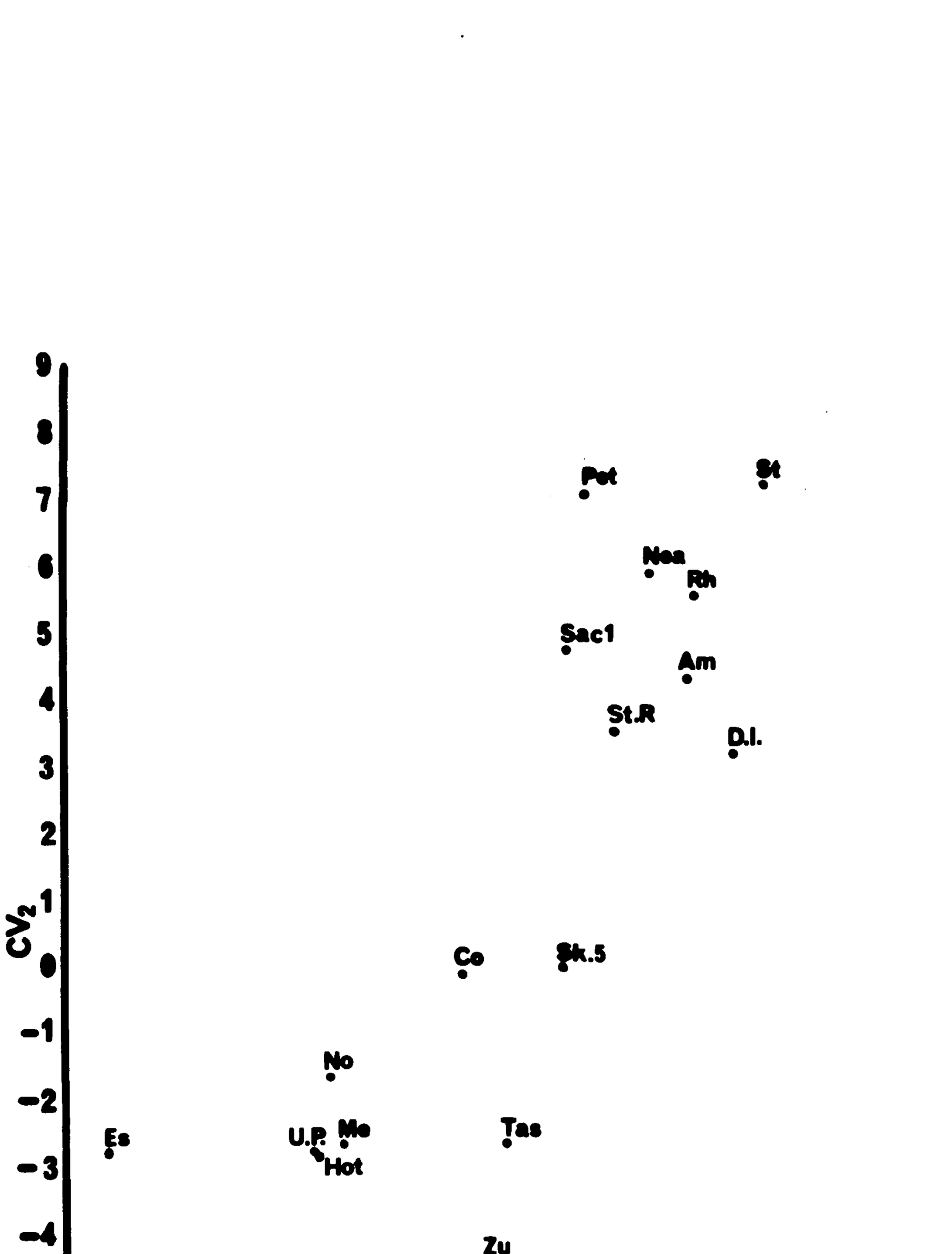
Analysis 14 Cranium - 25 variables (contd.)

Distance from Upper Palaeolithic

Neanderthal	-SOS	-XCB	-NLB	-PRR	+VRR	+PAC
Amud	-SOS	-NLB	-NPH	-GOL	-PRR	-XCB
Skhūl	-PRR	+NAR	-EKB	+ZOR	+VRR	-FRF
Saccopastore	+VRR	+PAS	-PRR	-NLB	+FRC	-XCB
Mesolithic	-FRF	+GOL	-MAB	-XCB	+EKR	+NPH
Norse	+EKR	+VRR	+PAC	+EKB	-OBH	+AVR
Zulu	+AUB	+SSR	-NLB	+ASB	+EKR	+FRF
Tasmanian	+ZOR	+NPH	+VRR	-NLB	+EKR	+EKB
Eskimo	-OBH	+EKB	+GOL	+SOS	+PAC	-WMH
Cohuna	-FRF	+PRR	+FRS	-SOS	-MAB	-GOL
Petralona	-EKB	-NPH	-FRF	-PRR	-SOS	-WMH
Djebel Irhoud	+PAS	-PRR	-SOS	-NLB	+VRR	-XCB
Hotu*	+NLB	+ZOR	+AUB	+OBB	-FRF	+OBH
Rhodesian	-SOS	-PRR	-FRF	+VRR	-NPH	+ZOR
Steinheim	-SOS	+VRR	+ZOR	+PAC	-NLB	+AUB
Steinheim reconstruction	+FRC	-SOS	-EKR	-NLB	-PRR	-AUB

Fig. 50

Analysis 14 (skull - 25 variables). Plot of canonical variates 1 and 2 for fossil and recent material.

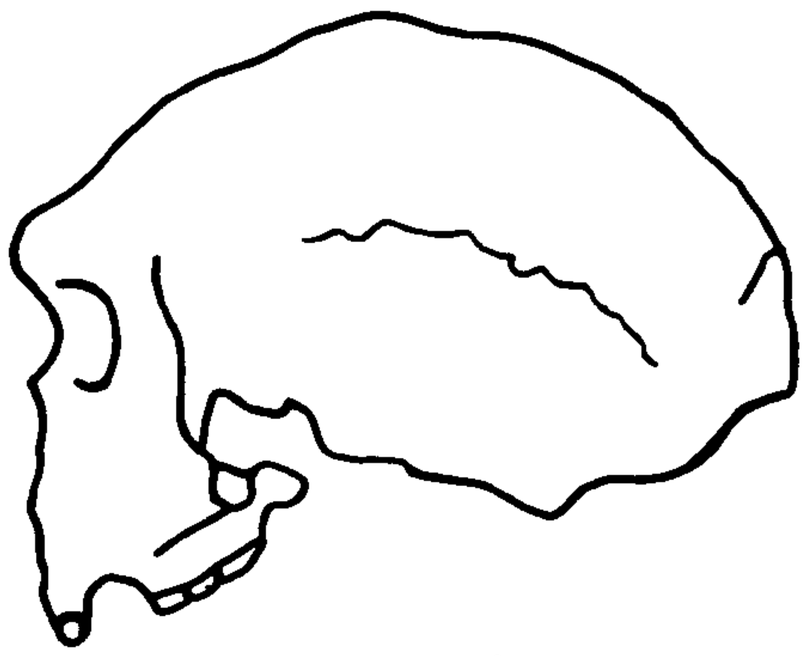

Pet
St
Nea
Rth
Sac1
Am
St.R
D.I.
Co
Sk.5
No
Es
U.P.
Mo
Hot
Tas
Zu
CV2
CV1
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-7
-6
-5
-4
-3
-2
-1
0
1
2
3
4

CHAPTER FOUR: DISCUSSION

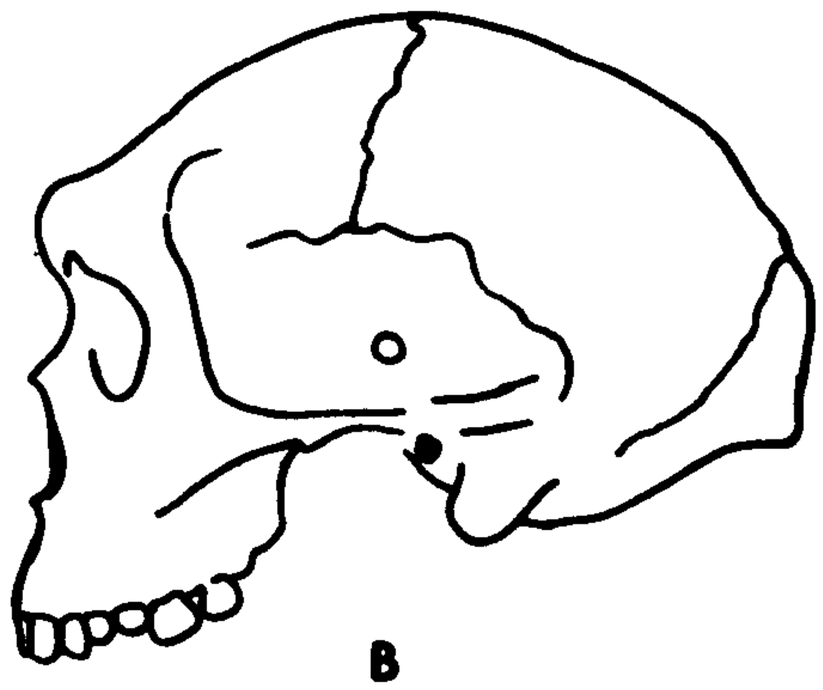
Fig. 51

Comparative lateral views of fossil human crania. A - "Pithecanthropus" VIII; B - Rhodesian; C - Petralona; D - Swanscombe; E - Saccopastore 1; F - Monte Circeo; G - Djebel Irhoud 1; H - Cro-Magnon 1.

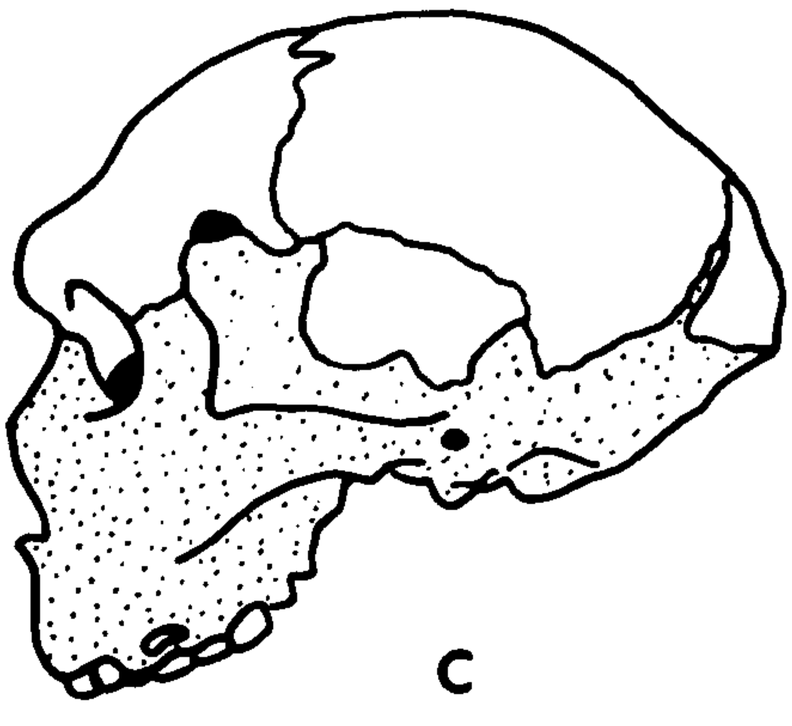
All except A were drawn from the author's photographs of original or cast material (A is reversed from a photograph in Sartono , 1971).



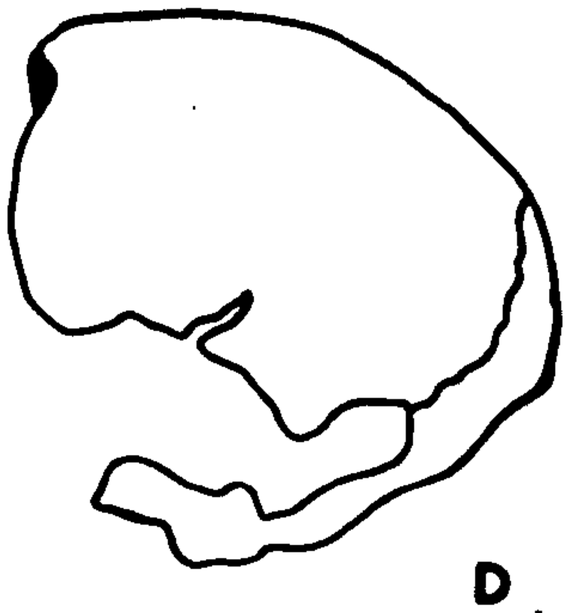
A



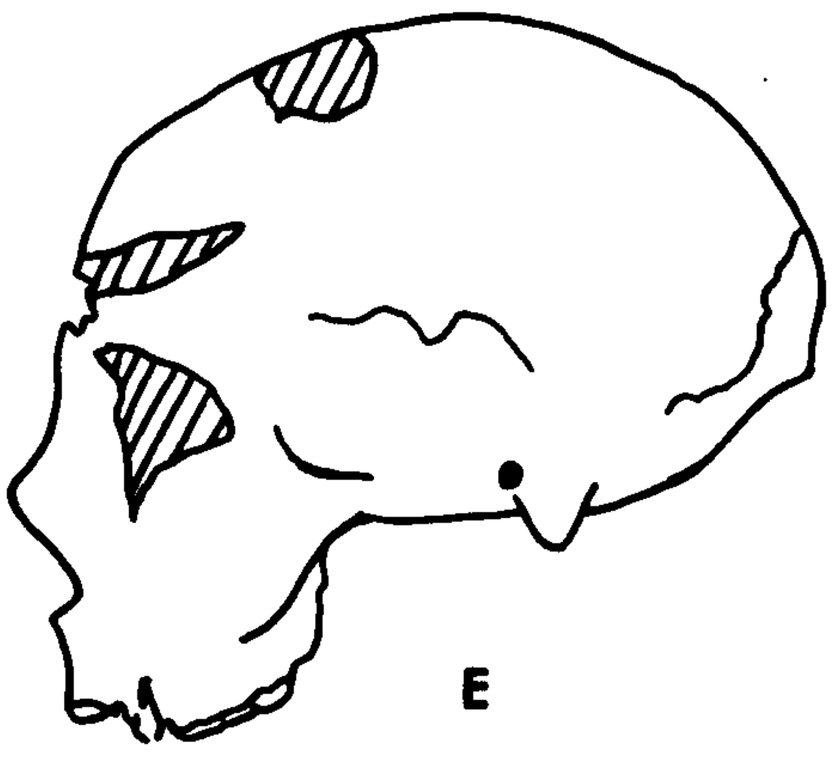
B



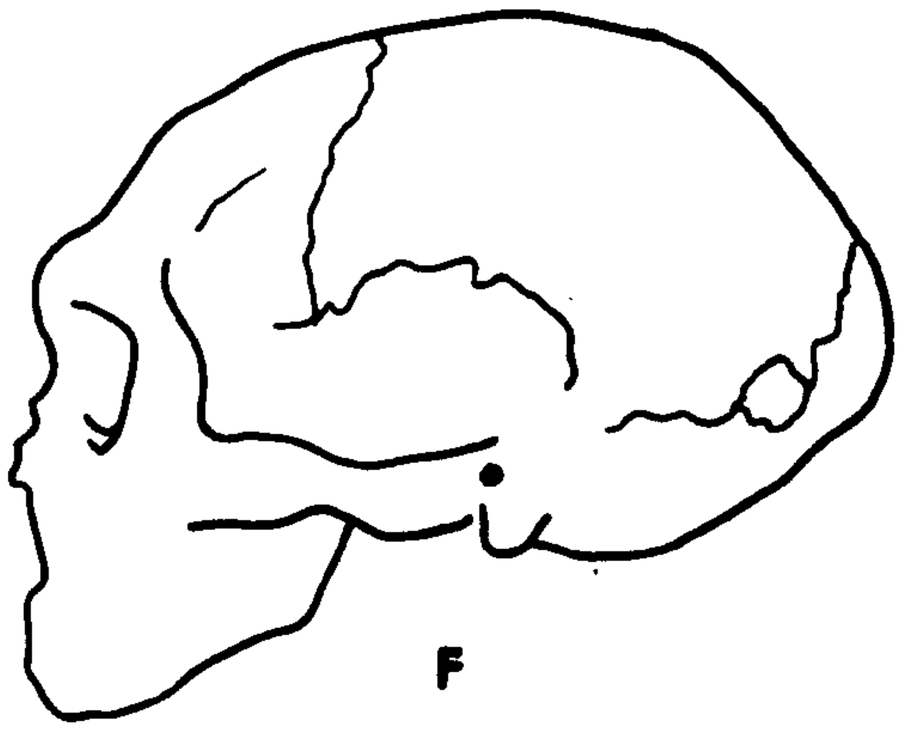
C



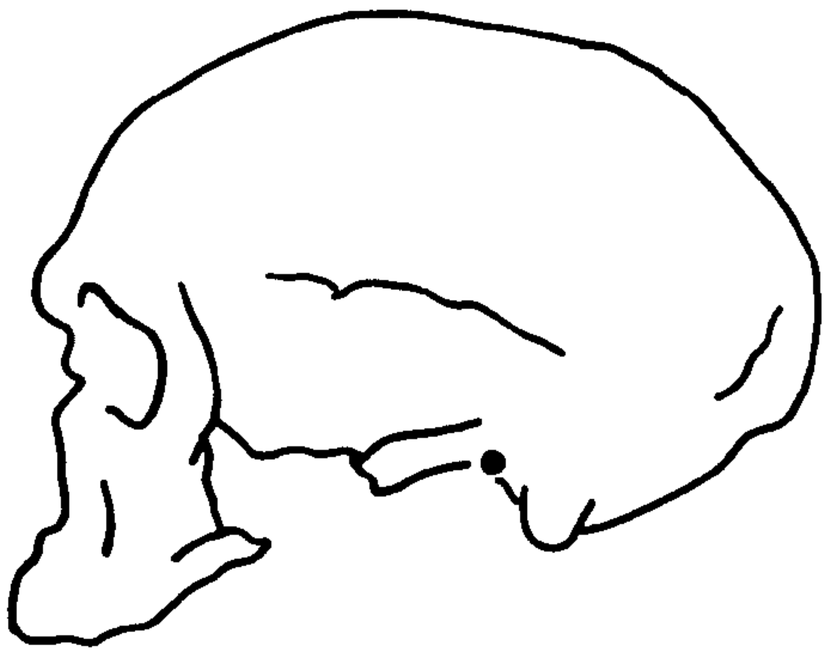
D



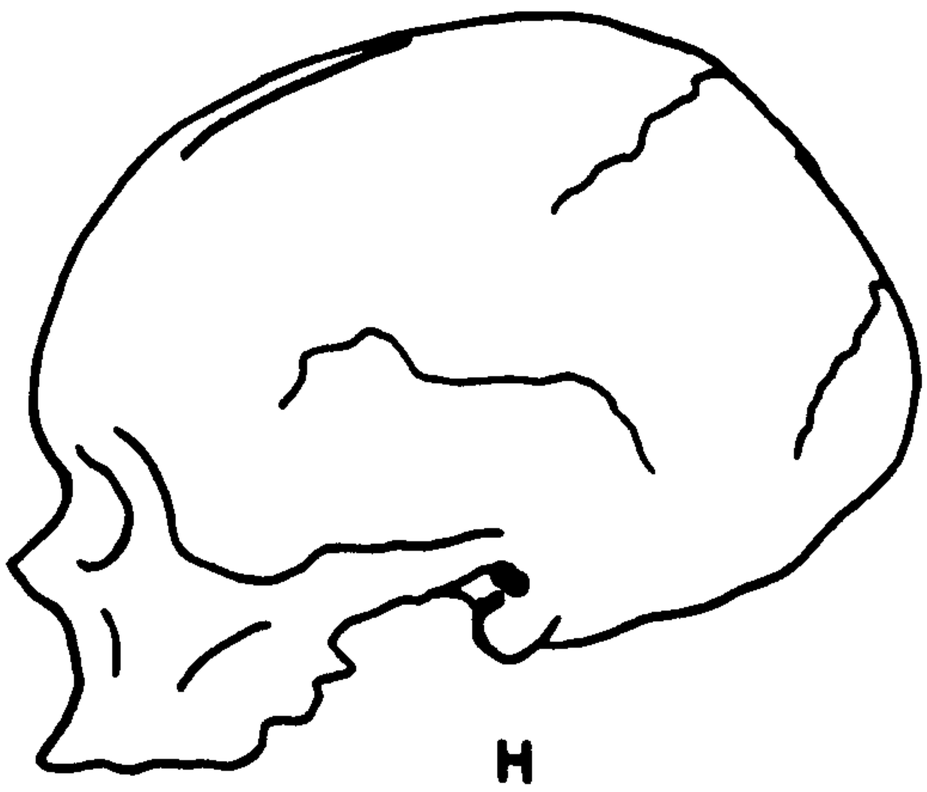
E



F



G

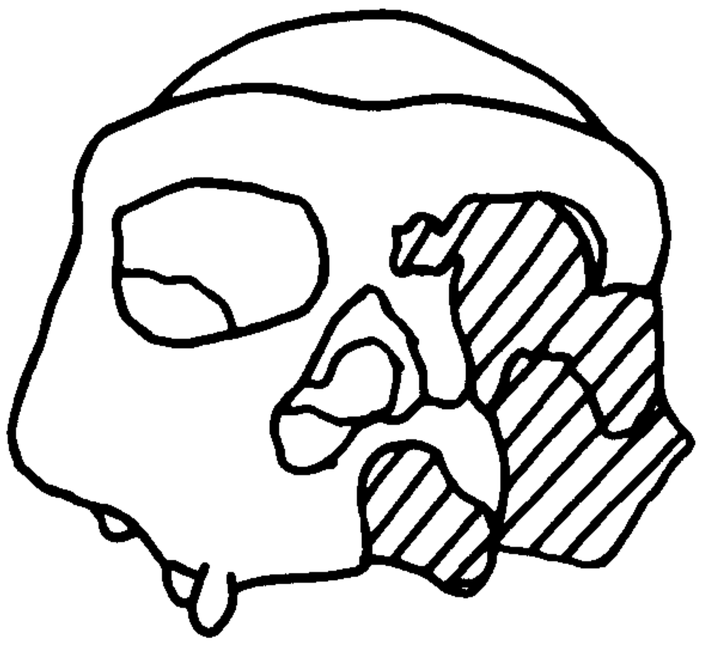


H

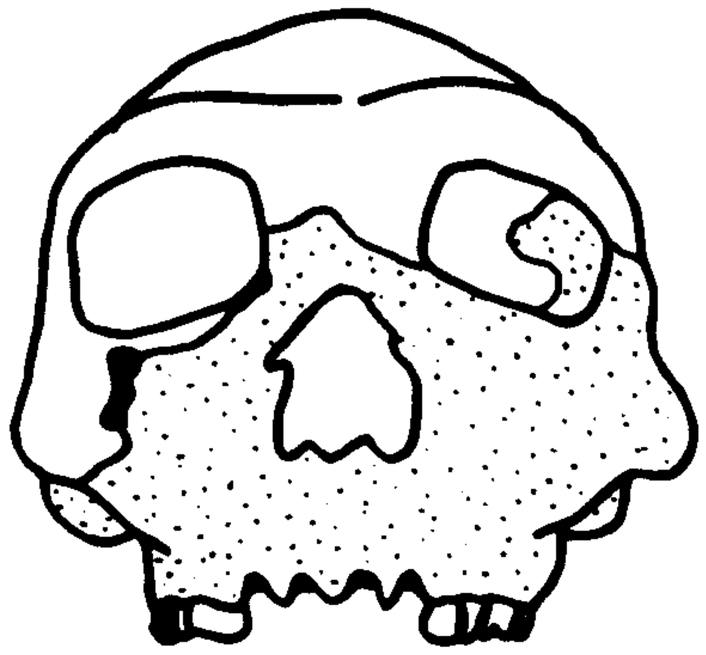
Fig. 52

Comparative facial views of fossil human crania. A - "Pithecanthropus" VIII; B - Petralona; C - Rhodesian; D - Steinheim; E - Saccopastore 2; F - La Chapelle; G - Djebel Irhoud; H - Cro-Magnon 1.

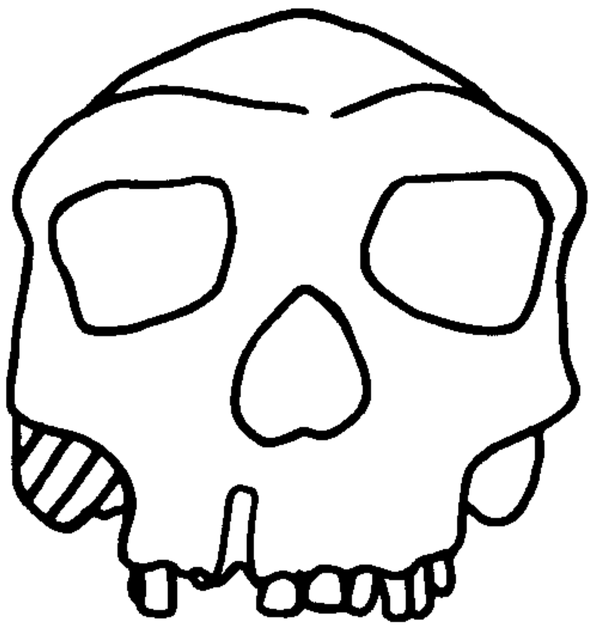
All except A were drawn from the author's photographs of original or cast material (A is from a photograph in Sartono, 1971).



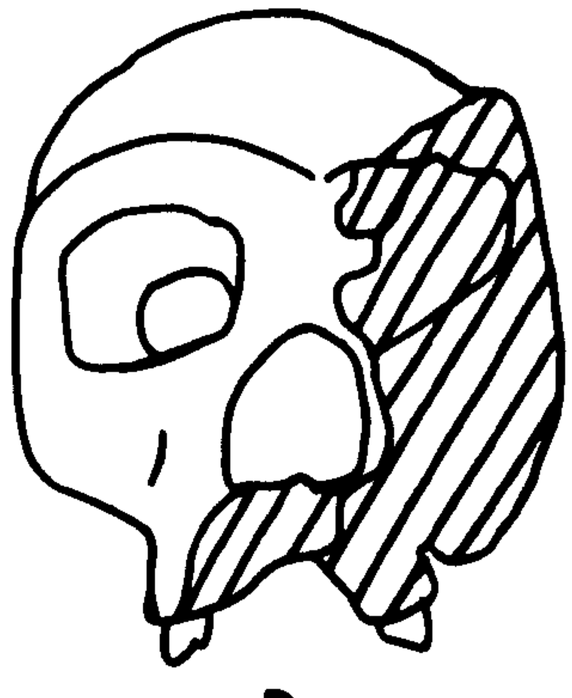
A



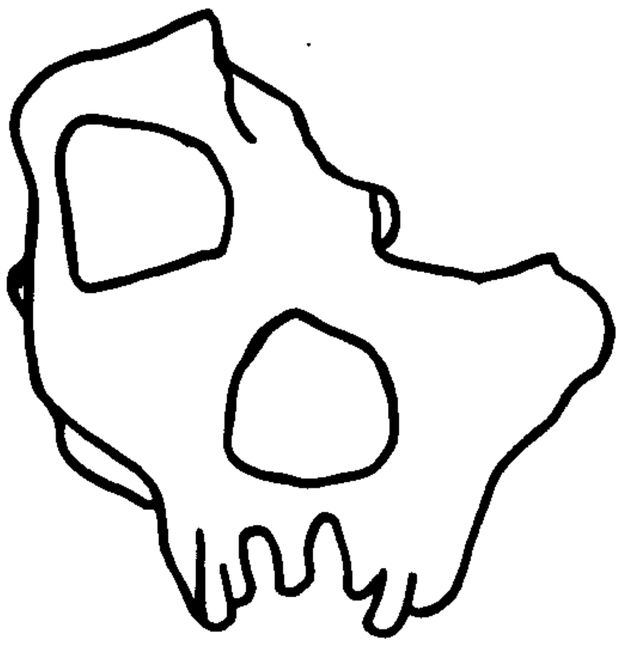
B



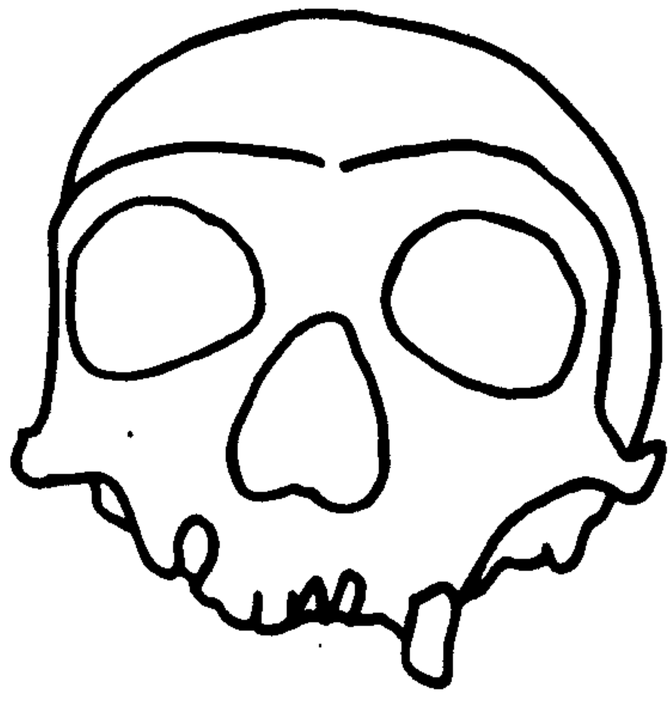
C



D



E



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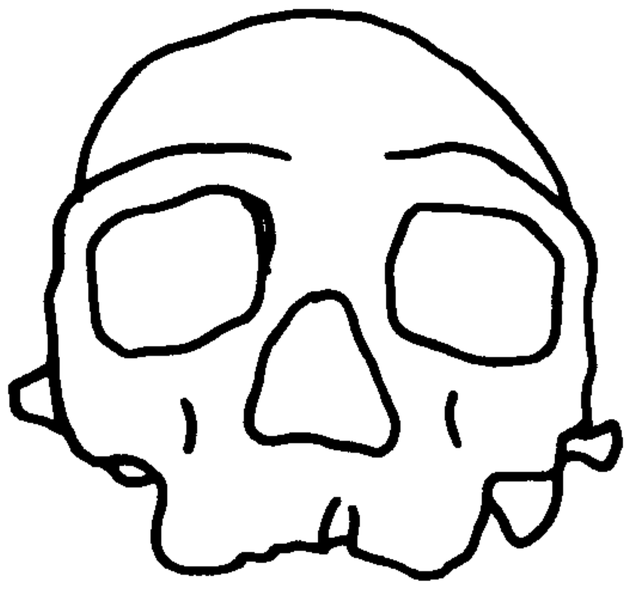

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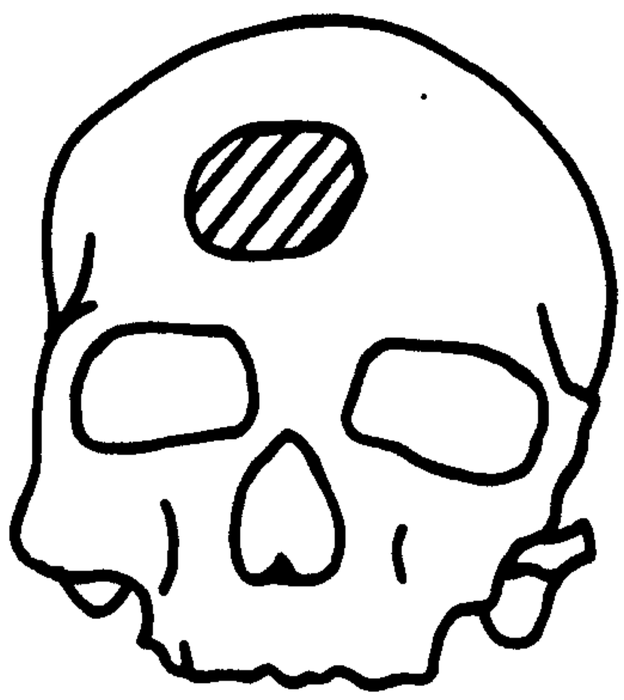
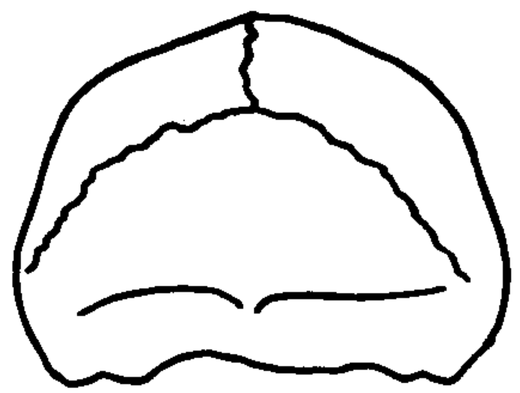


H

Fig. 53

Comparative occipital views of fossil human crania. A - Pekin E; B - Solo X1; C - Rhodesian; D - Petralona; E - Swanscombe; F - Fontéchevade; G - Djebel Irhoud; H - La Ferrassie; I - Cro-Magnon 1.

All drawn from the author's photographs of original or cast material except B (from Weidenreich, 1951).



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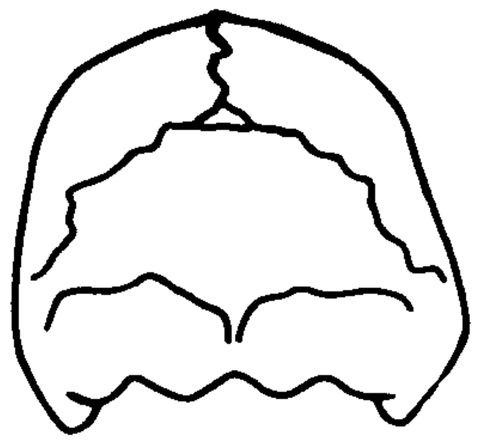

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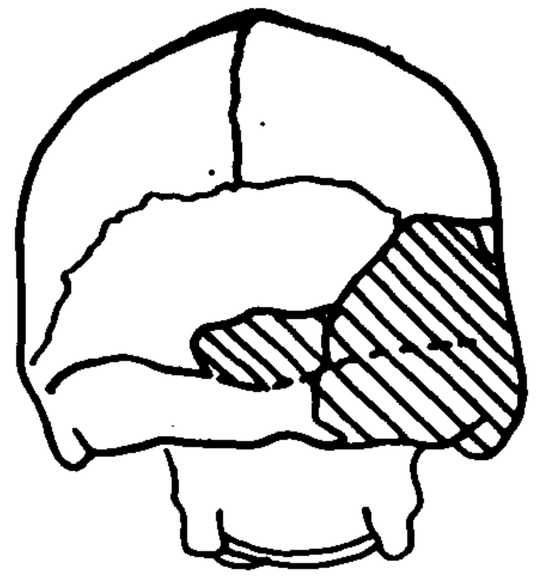

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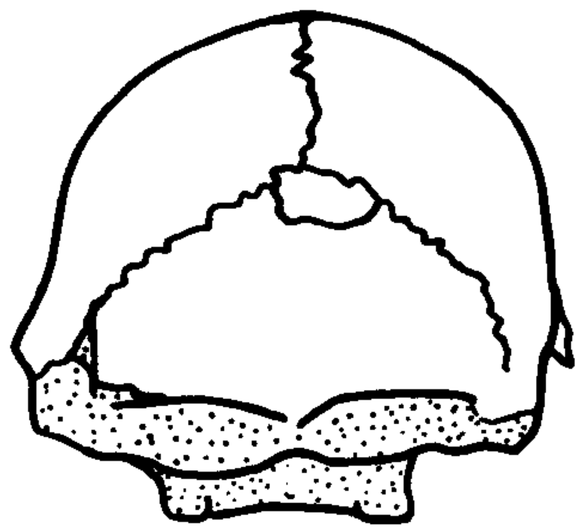

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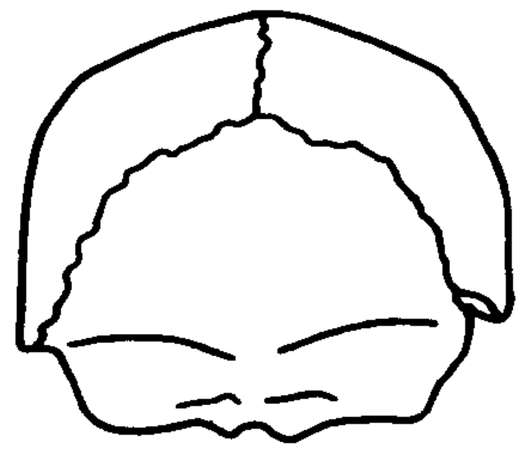

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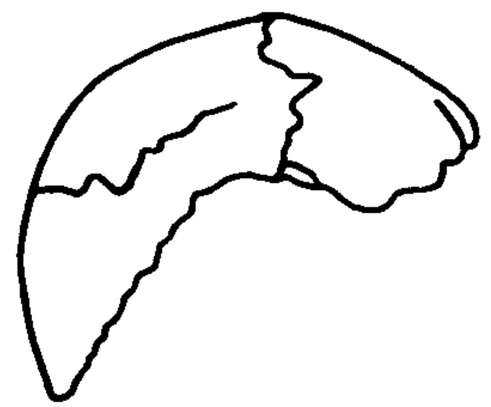

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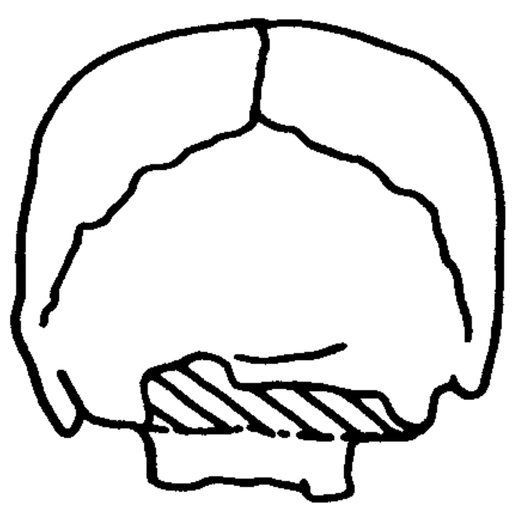

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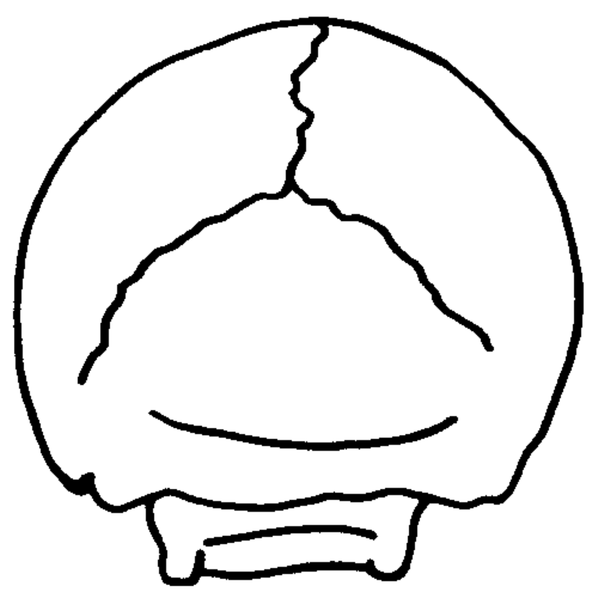
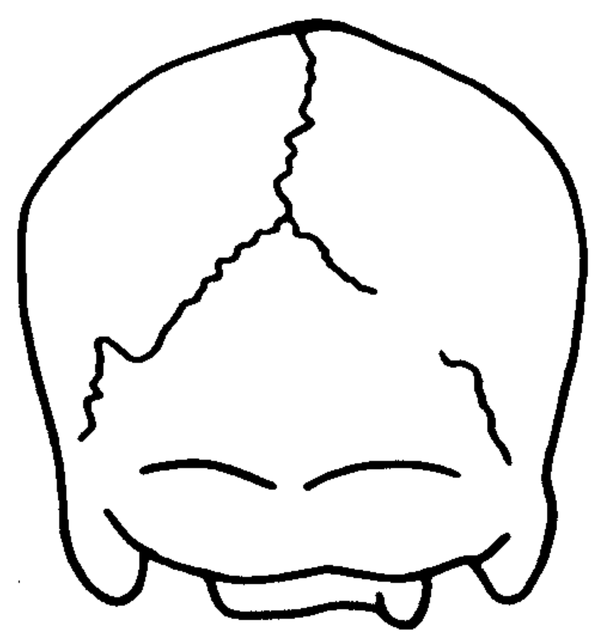


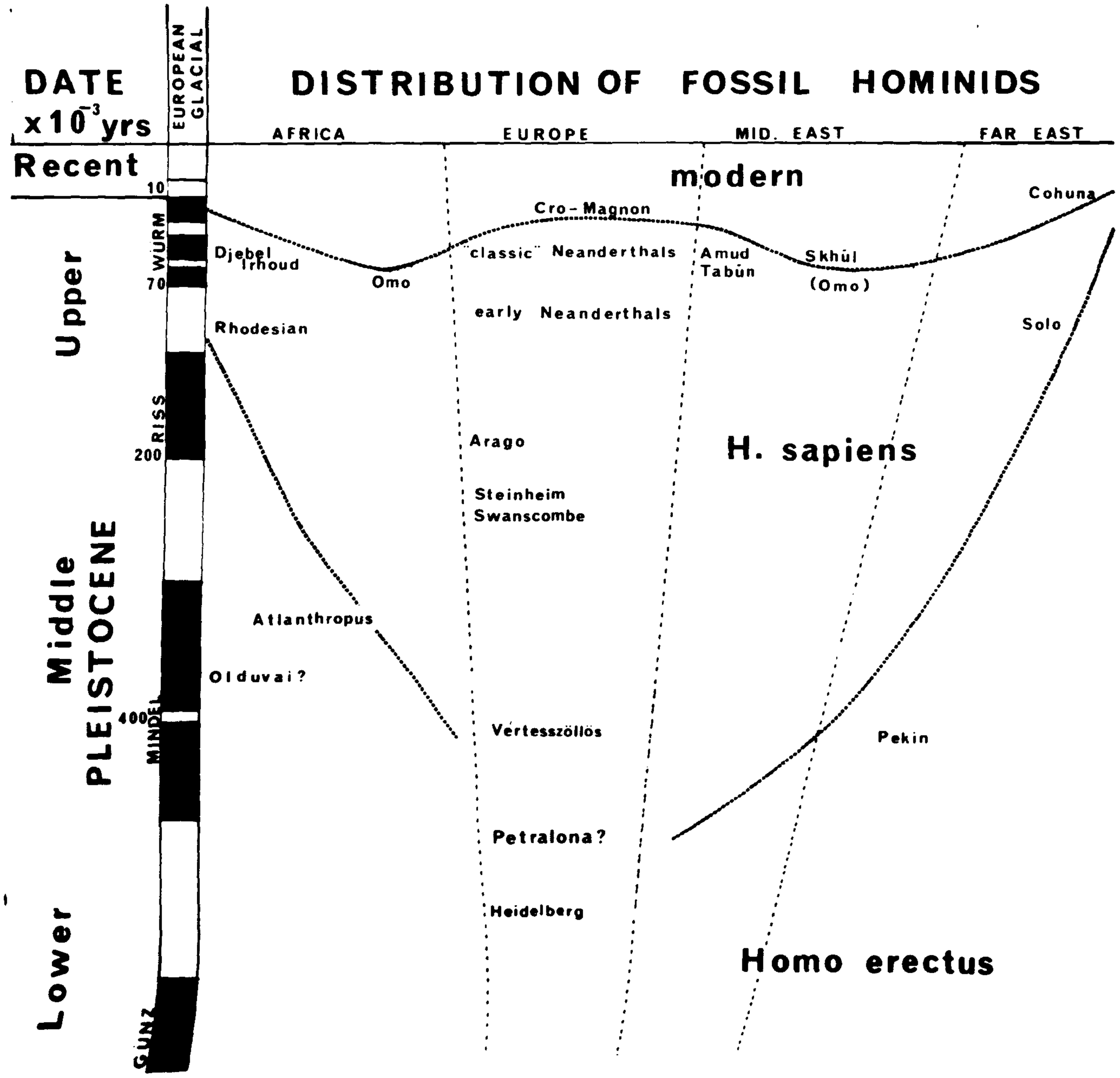
H



I

Fig. 54

Diagram of the distribution of later Pleistocene fossil hominids in time and space, according to the present author.


DATE
x10⁻³yrs
EUROPEAN GLACIAL
DISTRIBUTION OF FOSSIL HOMINIDS
AFRICA
EUROPE
MID. EAST
FAR EAST
Recent
10
modern
Cro-Magnon
Cohuna
Upper
WURM
70
Djebel Irhoud
Omo
"classic" Neanderthals
Amud
Tabūn
Skhūl
(Omo)
early Neanderthals
Rhodesian
Solo
RISS
200
Arago
H. sapiens
Steinheim
Swanscombe
Middle PLEISTOCENE
Atlanthropus
Olduvai?
400
MINDEL
Vértesszöllös
Pekin
Petralona?
Heidelberg
Lower
GÜNZ
Homo erectus

(1) Discussion

In the following discussion of the results, the author will first describe the morphological affinities of the various fossils studied, primarily in terms of the results of the D^2 analyses and the information gained about the relative importance of variables in discrimination between groups. Secondly an attempt will be made, using the morphological characters of the fossils studied, to identify "primitive" or "advanced" characters in the evolution of the species Homo sapiens. Thirdly the results will be used to throw light on the postulated theories of Pleistocene human evolution, and concluding remarks will be presented concerning the implications of the results for the phylogeny and taxonomy of Pleistocene human populations.

Concluding remarks from results

Pekin

The Pekin remains generally resemble the other non-modern material in the analyses, particularly the Rhodesian Solo and Neanderthal crania. The characters of Homo erectus which set Pekin apart from the later forms include a long narrow frontal bone with a low nasion-subtense fraction, a very short and low parietal bone, and a very short occipital chord and subtense fraction, coupled with a high occipital subtense. The characters of the occipital bone confirm the visual impression of a short highly angled bone with a large nuchal area facing backwards and upwards to the occipital torus. When extra variables of cranial size were included beyond those of the individual frontal, parietal and occipital bones, discrimination

between Pekin and other groups was greatly enhanced since the higher biauricular breadth and lower bifrontal chord and vertex radius were in contrast to most later crania.

In some respects the Pekin crania seemed more "advanced" compared to other material in the analyses. For example the frontal bone seemed higher than in forms such as Solo or Krapina, and the supraorbital projection was less than in the Neanderthals, Djebel Irhoud, Rhodesian and Petralona. The parietals were, as would be expected, longer and higher than those of "Pithecanthropus" 2, whilst cranial breadth was narrower than in some later forms (for example the Neanderthals, Skhūl and Omo 1). The "primitive" features of the occipital bone were matched by Petralona and Rhodesian (higher occipital subtense) and by the Solo, Neanderthal, Rhodesian, Omo 2, Swanscombe and Vértesszöllös remains (large biasterionic breadth).

Interestingly the classic Neanderthals often seemed to resemble Pekin more closely than did some earlier forms. The modern forms became increasingly distant from Pekin as more variables were added to the analyses, whereas in the canonical variates analyses and the dendrograms, Pekin was increasingly associated with the Petralona skull.

Petralona (see Table 15)

Cranially the Petralona skull was fairly close to the Neanderthals and very distinct from the modern populations. As previously mentioned, it even grouped with the Pekin crania in dendrograms 6, 7, 8, although it was more "advanced" in the form of the parietal bone (larger bregma-lambda chord, subtense and fraction) and in cranial height. Compared to both the Pekin and modern

material the skull was closer to the Neanderthals in cranial breadth, supraorbital projection, nasion-subtense fraction and occipital and bifrontal chords. Nevertheless there were a number of differences which could be regarded as archaic - these included the higher lambda-opisthion subtense, the greater bifrontal and biauricular breadths, and the narrower bistephanic breadth.

Facially, the Petralona skull occupied a unique position, being distant from the "classic" Neanderthals and modern forms. Facial parameters which differentiated Petralona from the late European Neanderthals included the greater zygomaxillary, prosthion and ectoconchion radii and the smaller zygorbitale, M_1-alveolus and nasion radii as well as a narrower nose and lower orbit height. This suggests that Petralona did not display the lateral facial recession of the orbits and cheekbones, nor the medially projecting middle face which characterised the Würm Neanderthals, and explains why the non-classic forms (such as Saccopastore 1 or Krapina) were closer to Petralona in these analyses.

The skull displayed what could be regarded as archaic characteristics including the large palate, large breadth of the upper face (bifrontal, biorbital breadth) and orbits which were relatively small, indicating that the orbital margins and interorbital region were massive and thick.

Overall the Petralona cranium showed closest resemblance to the Rhodesian and Djebel Irhoud skulls. Facially it was very distinct from the Neanderthals and Steinheim, but the non-classic Neanderthals (such as Saccopastore, Krapina or Amud) and Skhūl 5 were rather clos

Analysis	6	7	8	9	10	11	12	13	14
No. of vars.	15	13	17	9	8	9	11	25	25
Area	vault	vault	vault	radii	face	face	face	skull	skull
Fossils									
Upper Palaeolithic	100.2 (21)	102.7 (23)	122.2 (19)	40.11 (16)	55.02 (18)	67.56 (20)	99.45 (20)	236.0 (13)	187.1 (17)
Skhul 5	41.66	40.50	50.14	16.70	N.S.	30.68	46.73	132.6	67.70
Omo 2	60.45	82.70	96.80	-	-	-	-	-	-
Djebel Irhoud	29.51	26.68	37.74	N.S.	N.S.	38.38	49.62	89.60	52.50
Rhodesian (Broken Hill)	N.S.	31.52	27.10	30.92	22.56	30.49	32.50	116.5	46.22
Amud/Tabun	-	33.03 (2)	-	17.15	28.66	25.40	57.09	122.4	71.90
Neanderthal	N.S. (3)	37.11 (8)	52.79 (3)	32.39 (4)	76.17 (4)	75.92 (4)	107.0 (4)	157.7 (2)	107.8 (4)
Krapina C	-	-	-	-	47.01	-	76.54	-	-
Saccopastore 1 and 2	N.S.	-	-	N.S.	27.05 (2)	28.53 (2)	-	-	84.40
Steinheim	-	79.60	-	-	67.29	101.6	89.20	-	120.4
Steinheim recons.	40.60	71.82	88.60	30.92	56.53	55.44	78.80	209.0	96.50
Solo	39.09 (4)	32.47	52.74	-	-	-	-	-	-
Pekin	27.02	49.09	60.15	-	-	-	-	-	-

Samples are of single specimens except where indicated by bracketed figures. Values are corrected for difference in sample size and are significant at the 5 level except where marked N.S. Analyses 13 and 14 on the complete skull used 37 different variables between them.

TABLE 15 Generalised distances (D^2) of fossil crania from the Petralona skull

as, in some cases, were the modern populations. Similarities to Rhodesian man can probably be explained by common retention of residual Homo erectus features, and similarities to Djebel Irhoud by that skull's "unspecialised" Neanderthal form. Certainly Petralona is not a "classic" Neanderthal in its morphology, and could well date to pre-Mindel times as Hemmer (1972b) and others have suggested. The combination of a basically Neanderthal cranium (although with some primitive features) and a massive face demonstrates that cranial evolution in Europe proceeded at a fast rate, a fact which remains from Vértesszöllös and Swanscombe have already suggested.

Vértesszöllös

Although only four measurements were taken on a cast of this occipital bone, some tentative conclusions can be drawn about its likely affinities. It certainly appeared to be more "advanced" than the Pekin crania, which may be contemporaneous, in its greater length and reduced nuchal area (judging by the position of the maximum occipital subtense). It also appeared to be larger than most of the Neanderthal and modern material in all dimensions, which would certainly appear to indicate a cranial capacity above that of Homo erectus, however primitive the rest of the skull. To summarise, although it was not differentiated from several early populations in analysis 3 (including the Neanderthals, Skhūl 5, Omo 1 and Swanscombe) its position as an early "sapiens" form was supported, and its affinities probably lie with succeeding European material such as Swanscombe.

Steinheim and the Steinheim reconstruction

In many ways these crania are intermediate between

the Homo erectus and Neanderthal populations, but are smaller and more delicate than might be expected. They possess a short narrow skull with a narrow upper face and small palate and biauricular breadth. These features contrasted markedly with the Petralona cranium, and to a lesser extent with the Neanderthals and modern populations, and seemed to indicate that by the Mindel-Riss interglacial European human populations had already undergone a reduction of facial and cranial robustness approaching that of the early Neanderthals.

The Steinheim reconstruction which was produced using the undistorted Swanscombe remains as a model was rather more modern in its cranial characteristics than the "original" Steinheim skull. The use of the larger Swanscombe cranial bones resulted in a relatively long parietal and occipital chord, compared with the original short frontal chord and facial measurements. This brought the reconstruction closer to later crania such as Saccopastore and Skhūl 5 and probably overemphasised its modern characteristics. Nevertheless, even the "original" cranium displayed some features which could be considered as more "advanced" than the Neanderthals. These included the short high frontal bone (perhaps due partly to distortion, and partly to the deeply set nasion accentuating the height of the frontal subtense), the small face, and the values of certain cranial angles which aligned Steinheim with modern populations rather than the classic Neanderthals. Overall the affinities of the Steinheim skull and reconstruction seemed to lie with Swanscombe and the early Neanderthals (especially Saccopastore 1).

Swanscombe

The Swanscombe occipital and parietal bones did not appear to be anatomically modern from the results of multivariate analyses and the plot of parietal measurements shown here. However in some ways the bones were more "advanced" than some later populations, including the Neanderthals. The occipital bone particularly demonstrated that the features shown by the Vértesszöllös occipital were not exceptional in European Middle Pleistocene populations. Swanscombe would seem, like Steinheim, to belong to a group allied to the early Neanderthals, and lacks the more extreme features of a relatively short broad parietal arch, and short protruding occipital displayed by the later Neanderthals.

Fontéchevade

With only five measurements possible on the Fontéchevade cranial fragments, and hence its inclusion in only one graph plot of parietal dimensions and one multivariate analysis, it could not be expected that the affinities of this controversial specimen could be settled. Despite the limited data available it can be said that on the available evidence the Fontéchevade remains did not display an anatomically modern pattern. The parietals possessed a short low arch with a high biasterionic breadth compared with modern populations, but were also separated from the "primitive" Pekin crania by virtue of a longer broader parietal arch with a higher bregma subtense fraction. The D^2 analysis did not significantly separate the Fontéchevade remains from such forms as the Neanderthals, Saccopastore 1, Petralona and Swanscombe, although the

closest remains dimensionally were the Rhodesian, Swanscombe and Saccopastore 1 parietals. Provisionally then, the Fontechevade 5 cranial remains would appear to belong to the early Neanderthal group on chronological and morphological grounds.

Krapina

Only two individuals from Krapina were complete enough to include in these analyses. The frontal bone E was short, low and narrow, coming closest in general form to Saccopastore 1 and Petralona. The facial remains C were basically of Neanderthal morphology but were more delicately built without the "classic" Neanderthal characteristics of a large nose and the receding lateral borders and projecting lower borders of the orbits. Thus on the evidence available, the Krapina material studied seemed to belong with the early Neanderthal populations and like Djebel Irhoud and Saccopastore often resembled modern populations rather more closely than did the classic Neanderthals.

Ehringsdorf

The Ehringsdorf cranium, as reconstructed by Dr. Behm-Blancke, was only included in the multivariate analysis of the frontal bones. It was distinct from the modern populations, with a shorter broader frontal bone and larger supraorbital projection, and was also distinct from the Pekin material by virtue of its greater height, bistephanic breadth and supraorbital projection. The analysis placed it within the Neanderthal group, not distinct from various forms including the Neanderthals, Saccopastore, Petralona, Rhodesian and the Steinheim reconstruction, and

it was also not differentiated from Skhūl 5. In general form it was closest to the Middle-East Neanderthals and Djebel Irhoud before correction of the D^2 values. The parietal bones were not included in the multivariate analysis because of the uncertain biasterionic breadth, but when given an average Neanderthal value for this dimension the parietal form appeared comparatively advanced in the graph plot of parietal measurements. The Ehringsdorf cranium seems neither particularly primitive nor modern in its metrical characteristics, and probably belongs in the early Neanderthal group.

Saccopastore

The Saccopastore crania seemed closely similar to the classic Neanderthals in morphology, but deviated somewhat in possessing smaller, shorter skulls and, as far as could be judged, smaller brow ridges. The rear of the more complete specimen appeared most similar to Swanscombe, Steinheim, Djebel Irhoud and the Neanderthals. However facially the less projecting upper and middle face coupled with a relatively great biorbital breadth and cheek height were features also shown by Petralona. Similarly the greater projection of zygomaxillare indicates that the cheekbones were not swept back in the fashion of the classic Neanderthals, although zygorbitale projects forward compared with modern populations. To summarise, these crania represent a good ancestral model for the "classic" Neanderthals but if so, they are also good evidence for the specialisation of the Würm Neanderthals compared to earlier forms and populations outside Europe.

Solo

The Solo crania were similar to the Neanderthals and Pekin in general morphology. The skulls were long and low with short flat parietal arches and short broad protruding occipitals. However the measurement of the occipital subtense did not differentiate between projection due to an occipital torus and that due to an occipital "bun" which may explain some similarities between these forms. The Solo material seemed more "advanced" than the Pekin crania in the higher vertex radius, parietal chord, bifrontal chord, lambda-opisthion fraction and bistephanic breadth, combined with a lower supraorbital projection. Nevertheless the Solo skulls had flatter frontal bones with a greater biasterionic breadth. Compared to the Neanderthals the shorter occipital chord, flatter parietals and larger biauricular and biasterionic breadth seemed more "primitive". In addition the narrower cranial breadth, reduced supraorbital projection and higher lambda-opisthion subtense were not typical Neanderthal characteristics.

Weidenreich (1951) was aware that in certain angles and indices the Solo material resembled the Neanderthals, but in other morphological characters he believed that Solo man was "distinctly more primitive and very close to Pithecanthropus and Sinanthropus."

Probably the Solo population were evolved forms of hominids such as the Homo erectus populations of Java and Pekin, paralleling in various ways evolutionary changes which led from Homo erectus to Homo sapiens elsewhere in the world. The surprising similarities of Solo to Omo 2, especially with larger numbers of cranial measurements,

suggest that such a form could have given rise to later Homo sapiens populations. However the Upper Pleistocene age of the Solo material, if correct, coupled with the great distance of the Solo crania from the Tasmanians and Cohuna did not support the Weidenreich-Coon polyphyletic evolutionary theory.

Saldanha

Throughout the analyses in which it could be included there was little discrimination between Saldanha and most of the earlier populations, and in some cases there was no significant difference in the D^2 analyses between Saldanha and modern populations. In general it resembled the Neanderthal and Solo populations most closely and was certainly more "advanced" than the Pekin group. In some ways, however, the larger parietal chord and subtense, smaller biasterionic breadth and supraorbital projection were less Neanderthalian and suggested possible affinity with the Omo and Iwo Eleru crania.

Rhodesian (Broken Hill)

Cranially the Rhodesian skull was more "advanced" than Pekin, having a larger cranial height, a relatively longer frontal and parietal chord, and also a greater bifrontal chord. It was generally closest to the Neanderthals, Solo and Singa before correction of the D^2 results, but differed from the Neanderthals in the greater lambda-opisthion subtense, lower and longer frontal bone, longer parietals and a narrower cranial breadth.

Facially the Rhodesian skull was very distinct from modern populations in the large breadth of the upper

face and palate, the longer face with larger orbits, the large glabellar and supraorbital projection and nasal breadth, and the relatively great prosthion and M1-alveolar projection. However the differences from the classic Neanderthal pattern were in some ways as marked and lay in the same direction as those shown by Amud, Djebel Irhoud, Saccopastore and Petralona. These differences were primarily in the relatively broad but short upper face (with high biorbital, bijugal and bifrontal breadths), higher glabellar projection, narrower nasal, zygomatic and cranial breadths, and the less prominent zygorbitale, nasion and subspinale radii.

To summarise, the Rhodesian skull was closest cranially to the Neanderthals and Solo populations, and facially closest to Amud, Djebel Irhoud and the early Neanderthals. It was also the most similar in general form to the Petralona cranium of all the material included in the analyses. Morphologically the Rhodesian skull would appear to be rather "primitive" amongst Upper Pleistocene crania, and the recent reassessment of its dating by Klein (1973) would support this contention.

Neanderthals

The European Neanderthals of the Würm were apparently highly evolved compared with the Pekin crania. They displayed a greater cranial height and breadth, longer parietal and occipital bones, broader frontal bones with a greater bistephanic breadth, and a smaller biauricular breadth and lambda-opisthion subtense. Other features which differentiated the Neanderthals from the Pekin crania were the increased supraorbital projection and biasterionic

breadth, but the generalised distances involved suggested that the shape differences between these populations were not in fact great, and were primarily due to the increase in cranial height and breadth, probably related to the great increase in cranial capacity. Interestingly the Neanderthals had frontal bones which in some ways seemed more "primitive" than those of the Pekin crania in the greater supraorbital projection and lower frontal subtense. These and other characteristics are surprising if an evolutionary sequence exists from late Homo erectus forms like Pekin to modern populations via the Neanderthals of Europe. Alternatively the Neanderthals may have evolved from a population which already showed such features of the frontal bone, for example the population represented by Petralona.

Compared with modern populations, the Neanderthals showed a unique combination of characters, and an increasingly great D^2 distance as more variables were included in the analyses. Some of these characters were shared by crania such as Amud and Saccopastore, but the morphological distances between Steinheim, Petralona and the Neanderthals increased markedly as more measurements were used in the D^2 analyses. There seems little evidence to link the Omo and Skhūl crania to the Neanderthals, but other forms such as Djebel Irhoud and the Rhodesian skull showed affinities with the Neanderthals in various analyses, especially cranially. To what extent these similarities are due to a common retention of ancestral characteristics is uncertain.

Facially the Neanderthals were characterised by a

long and projecting middle face from nasion to subspinale, including zygorbitale, but the lateral portions of the face are retracted with a relatively low ectoconchion and zygomaxillare radius. The upper facial breadth was relatively reduced and the orbital borders and interorbital breadth were reduced in thickness compared with earlier and contemporary populations. Additionally the graph plots of angles such as the zygomaxillary, nasio-frontal and basion and nasion angles (figures 4, 5, 6) confirmed the uniqueness of the facial morphology of the Neanderthals, compared with forms such as Petralona, Djebel Irhoud and Steinheim.

The high values of the zygorbitale radius coupled with low values of the ectoconchion radius differentiated the Neanderthals from Amud, Krapina C, Petralona, Djebel Irhoud, the Rhodesian skull, and both the original and reconstructed Steinheim crania.

Morphologically the Neanderthals seemed to represent unlikely ancestors for the Upper Palaeolithic population, particularly as the Upper Palaeolithic group seemed even further from the Neanderthals in many analyses than various recent human populations. The differences were marked cranially in the Neanderthals (including the larger supraorbital projection, cranial breadth, nasio-occipital length, lower parietal chord and vertex radius) and facially (for example the larger nasal breadth, nasion-prosthion height, bimaxillary chord and prosthion, M1-alveolus, nasion, ectoconchion and subspinale radii).

Middle-east Neanderthals

Apart from the inclusion of the Galilee frontal bone, the cranial data on the Middle-east Neanderthals was drawn only from the Tabūn 1 and Amud crania. The results of

analysis 7 showed that these crania were very similar to the Neanderthals, but possessed shorter, less broad skulls with shorter, higher frontal bones and a greater biasterionic breadth. Facially the data was only drawn from the Amud skull, reconstructed in part from the morphologically similar Shanidar cranium. It suggested less extreme "classic" Neanderthal characteristics with a lower subspinale and prosthion radius, a higher zygomaxillare and ectoconchion radius, and a broader upper face (biorbital, bijugal and bifrontal breadths) and a broader palate than the European Würm Neanderthals. In some ways the Amud cranium was more "modern" than the European Neanderthals in possessing a higher frontal bone and vertex radius, larger mastoid length, and a lower bizygomatic breadth. But the overall differences from the other Neanderthals were not large, whereas the general morphology of a long low skull, long face with wide nasal breadth, large supraorbital projection, short broad parietal arch and high orbits differentiated Amud not only from the Upper Palaeolithic and recent populations, but also from Skhūl 5. However the similarities of Amud to Djebel Irhoud, and the similarities of this latter skull to Skhūl 5, suggest that a "spectrum" of varieties existed around the Mediterranean at the time of the Würm ranging from the "classic" forms of glaciated Europe to the slightly less extreme Middle-Eastern forms such as Amud, to the rather generalised Djebel Irhoud skull of Morocco. It is this form without the typical Neanderthal facial morphology, which seems closest to Skhūl 5 in the D^2 analyses out of all the "Neanderthals".

Djebel Irhoud

Cranially this skull resembled the early and

Middle-Eastern Neanderthals most closely, and to a lesser extent the classic Neanderthals and Skhūl 5. It exhibited the typical differences of Upper Pleistocene material from the Middle Pleistocene Pekin crania. These included the longer parietal and occipital chords, greater skull height, wider bifrontal and biparietal breadths, and greater lambda-subtense fraction. It exhibits too a higher nasion-bregma subtense than both Pekin and the Neanderthals, and differs from the Neanderthals in possessing a longer lower parietal, a shorter narrower frontal bone, and a shorter glabella-occipital length. Compared with the Upper Palaeolithic populations Djebel Irhoud has a flatter, broader parietal arch, shorter occipital chord, and a frontal bone characterised by larger values of the supraorbital projection, bifrontal chord and nasion-subtense fraction.

The differences between Djebel Irhoud and the classic Neanderthals are greater facially than cranially. Primarily these are due to the greater breadth of the upper face in Djebel Irhoud (biorbital, bifrontal breadths), the deeply-set nasion as in Skhūl 5 (giving relatively low values of the nasio-occipital length, nasion radius and nasio-frontal subtense), the shorter and narrower nasal opening, shorter orbits and narrower bimaxillary chord. The radius measurements especially showed that the face of Djebel Irhoud is of reduced size compared with the European Neanderthals, and the lower subspinale, zygoorbitale and M1-alveolus values were more like those found in the early Neanderthals. Thus metrically the Djebel Irhoud skull confirms its visual assessment as cranially a Neanderthal skull with some more "advanced" features of the vault, and with a non-"classic" face, flat and broad in the upper part and

prognathic in the lower part.

Overall the closest forms to Djebel Irhoud were Amud, the early Neanderthals from Saccopastore and Krapina, Skhūl 5 , and the Neanderthal and Rhodesian forms. But in several analyses, particularly those including facial parameters, crania such as Cohuna and Petralona were nearer to Djebel Irhoud than the "classic" Neanderthals. The position of the Djebel Irhoud skull, and its dating to a time earlier than or contemporary with the Neanderthals of the Middle-East and Europe, suggests that there was a widespread form of early Homo sapiens around the Mediterranean before the Würm glaciation. The similarity of the recently discovered Arago mandible to those of "Atlanthropus" (Stringer, unpublished study) supports this idea of related populations which lived during the Middle and early Upper Pleistocene around the Mediterranean from North Africa to Europe, and cultural evidence does not contradict this suggestion. In some areas (for example North Africa) this early Homo sapiens type may have persisted without much change, whilst in Europe before and during the Würm, the "classic" Neanderthal form developed with the accompanying modifications of the facial morphology.

In the case of Djebel Irhoud, this retention of "generalised" early Homo sapiens features may account for the similarities between that skull and the early Neanderthal, Rhodesian and Petralona material. The close relationship of Djebel Irhoud and Skhūl 5 in some analyses is further evidence that the modern forms sprang from an early Homo sapiens stock which had maintained a relatively "unspecialised" facial form distinct from the

"classic" Neanderthals. This idea is supported by the position of Djebel Irhoud, Steinheim and Petralona in the graph plot of the zygomaxillary and nasio-frontal angles (Figure 4). Whether a form such as Skhūl 5 had in fact evolved from a form such as Djebel Irhoud is very dependent on the dating of these crania. The Qafza material, which morphologically matches the Skhūl material closely (Vandermeersch, 1972) may well date to the beginning of the Würm of Europe (Farrand, 1972). In this case the Djebel Irhoud material was probably too late in time to have evolved direct into later modern populations, unless such evolutionary changes occurred much later in North Africa than in the Middle-East and Europe, for although Djebel Irhoud resembled Skhūl 5, it was still much more distant morphologically from the Upper Palaeolithic and more recent populations.

Singa

This skull which is generally dated to the late Upper Pleistocene (Oakley and Campbell, 1967) was surprisingly archaic morphologically in its very short flat parietal chord. On the other hand it displayed reduced supraorbital projection and a greater frontal subtense than forms such as the Neanderthals. It differed both from Pekin and the Neanderthals in its long but protruding occipital bone, and it also displayed a very short but broad cranial shape. The fact that the frontal and occipital bones were both relatively long and the parietal bones short compared with the Neanderthals, indicated an unusual morphology which has led Brothwell (personal communication, 1973) to suggest that the skull is abnormal. He considers that the skull exhibits compensatory lateral growth to

counterbalance an abnormally early closure of the sagittal suture which restricted further longitudinal growth of the skull. Furthermore he considers that the affinities of the specimen are not with the Bushmen (Woodward, 1938; Wells, 1951) but lie instead with the Neanderthals or related forms. The results of analyses given here support that view, although the late Pleistocene date is surprising considering the apparent affinities of Singa with the Rhodesian and Solo skulls.

Omo 2

Of the two crania from Omo included in the analyses the second specimen is more complete and also more difficult to designate. It differed from the Pekin material in possessing a higher skull with longer cranial bones, a greater bifrontal chord, reduced biauricular breadth and a smaller supraorbital projection. The morphological distance from Pekin increased markedly as more variables were included, but interestingly these same variables tended to bring Omo 2, Solo and Iwo Eleru closer together, and differentiated them from Pekin, the Neanderthals and modern populations. Compared with the Neanderthals, Omo 2 displayed a longer broader frontal bone with smaller supraorbital projection, a longer parietal with narrow cranial breadth but greater biasterionic breadth, and a higher vertex radius. Nevertheless the morphology was not modern, since differences from the Upper Palaeolithic forms included a longer skull with low frontals and parietals, and an apparently archaic occipital bone.

To accept that Omo 2 and Omo 1 were members of the same population would involve acceptance of an inordinately great degree of variability. However despite

the differences in parietal and occipital form between the two crania (Figures 2, 10, 11, 12, 13, 14, 15), there were similarities in total cranial form which suggest that some sort of evolutionary relationship between them is possible.

Omo 1

The affinities of this skull were somewhat clearer than was the case with Omo 2. It was generally closest to Skhūl 5, Iwo Eleru and morphologically modern populations from which it differed mainly in the longer frontal bone and subtense fraction, the greater cranial and bistephanic breadth and the supraorbital projection. Compared with the Neanderthals and Pekin it exhibited a longer broader frontal bone with reduced supraorbital projection, and parietals and occipital of modern form but with a greater biasterionic breadth and lambda-subtense fraction. The form of the frontal bone served to link it with Omo 2, as did the mutual resemblance to Iwo Eleru in the analyses, but in contrast to those crania it was not close in overall morphology to the Solo material.

If these crania were contemporaneous and came from deposits dating to the late Middle Pleistocene or early Upper Pleistocene (Leakey, Butzer and Day, 1969; Day, 1972, 1973), an extremely variable and so far unique population of Homo sapiens was in existence at that time in Ethiopia. They displayed a range of features found in Homo erectus and Homo sapiens, but these features were combined in "mosaic" fashion in some individuals. Certainly neither of the Omo crania can be termed "Neanderthal" without widening the meaning of that term beyond the point of usefulness, and their date, if confirmed, makes them more plausible ancestors

for later populations than African forms such as Rhodesian man, and European forms such as Neanderthal man.

Alternatively, the Omo crania could belong to two successive or contemporary populations, one related to evolved Homo erectus/early Homo sapiens populations such as Rhodesian or Solo, and the other representing a robust but anatomically modern population. A third alternative, which seems most plausible to the present author, is to view them as successive phases of an evolving Homo sapiens population with Omo 2 earlier than Omo 1. This would explain their similarities to each other without necessitating the acceptance of an unprecedented population variability, or the old belief in two hominid lineages coexisting with each other. Omo 2 is similar enough to Rhodesian man, the early European Neanderthals, Swanscombe and Fontéchevade to represent an evolution from the basic early Homo sapiens stock which the author has postulated existed in the Middle and Upper Pleistocene around the Mediterranean area. It is also similar to Iwo Eleru, and the late Pleistocene date of that skull implies that populations with an archaic sapiens form survived longer in some areas than in others.

To summarise, the evidence of the Omo crania suggests that populations of a robust but basically modern form existed in Eastern and Northern Africa in the early Upper Pleistocene. Other discoveries which could support this view have been sadly neglected. The Qafza crania from an apparently similar time-level have not been fully described, and the Kanjera material from Kenya should now be reassessed in the light of the Omo discoveries. It is to be hoped that further work at Omo will produce more complete material and settle the uncertainty over the true

chronological position of these important remains.

Iwo Eleru

The Iwo Eleru skull was extensively reconstructed and hence any conclusions about its affinities must be treated with some caution. It certainly appeared more "evolved" than the Pekin material particularly in the smaller supraorbital projection, longer frontal and parietal chords and higher vertex radius; but it also possessed a lower frontal (nasion-bregma) subtense and a greater bifrontal chord.

Compared to the Neanderthals the skull was in some ways more archaic morphologically, with a lower longer frontal bone, and a lower vertex radius, but on the other hand the supraorbital projection was reduced, and the parietal chord relatively long. But like Omo 2 and Solo it was comparatively primitive compared to the Upper Palaeolithic forms, in the long low skull with greater cranial breadth and "archaic" occipital region. However the magnitude of these differences were not great, and some recent populations (for example the Norse and Tasmanians) fell much closer to Iwo Eleru, as did Skhūl 5 and Omo 1.

Overall the affinities of this skull were with Saccopastore 1, Omo 1 and 2, Skhūl 5 and Solo. It was generally closer to recent populations than to the Neanderthals, but showed no particular morphological similarities to the modern Zulu population in the analyses. In view of its mixed "primitive" and "modern" features, the late Pleistocene date is very surprising and apparently indicates a survival of archaic sapiens characteristics like those of Omo 2 until a relatively recent date in West Africa.

Cohuna

This very interesting skull occupied a unique position in the analyses but overall was most similar to Skhūl 5 and Hotu. The frontal bone was unlike any other included in this study and is probably abnormal due to some form of cranial deformation as suggested by Brothwell (personal communication, 1973). The peculiar features of the long narrow frontal bone with a remarkably high nasion-subtense fraction are without parallel amongst Pleistocene hominids studied here. If this bone is not taken into account, the Cohuna specimen is generally of a very robust Homo sapiens sapiens form, with a parietal shape of entirely modern type. Facially the Cohuna skull showed closest resemblance to Skhūl 5 and the early Neanderthals, sharing with them the non-"classic" Neanderthal morphology of a lower subspinale and nasion radius and prominent cheek bones (high zygomaxillare radius). However the degree of sub-nasal prognathism was large (high prosthion and M1-alveolus radii compared to modern forms), and the upper facial breadth was large compared with both the Neanderthal and modern forms, as was the vertex radius. The face of Cohuna with its flat broad upper part and strongly prognathic lower part was extremely robust, but nevertheless was of a similar morphology to the Hotu, Zulu and Tasmanian groups. Such a morphology could have evolved into the modern Australian aboriginal facial form but the Kow Swamp material, which shows similar characteristics to Cohuna, is said to show features of the skull recalling Homo erectus (Thorne and Macumber, 1972). Cohuna certainly did not resemble the Solo material in the portions in which they could be compared, even in the frontal bone morphology,

and therefore it is to be hoped that a more detailed study of all this material can be made. The resemblances of Cohuna to the most robust Kow Swamp material, including the morphology of the frontal bone, is confirmation that this form of cranial vault and robust face was common in early Australian populations, at least in the Kow Swamp area. To what extent the frontal bone morphology was a local phenomenon, perhaps due to genetic, pathological or behavioural reasons, must await further research.

Skhūl

The Skhūl population was unfortunately only represented here by Skhūl 5 and, in the parietal analysis, Skhūl 9. The face of Skhūl 5 has been reconstructed on the basis of the other Mount Carmel material and by use of the relatively complete mandible, but the more complete face of Qafza 6 (Vallois and Vandermeersch, 1972) suggested that the reconstruction was essentially correct. In the parietals, Skhūl 9 was somewhat less modern than Skhūl 5 and when placed together they fell into the non-modern range closest to the early and Middle-Eastern Neanderthals (Figures 10, 11, 12). The graph plot of parietal measurements (Figure 2) showed, however, that Skhūl 5 was relatively "advanced" compared to earlier forms and fell into the modern range, as does Omo 1.

Cranially, Skhūl 5 was morphologically closest to Hotu, Omo 1, the Upper Palaeolithic and Mesolithic populations, and Djebel Irhoud. The Steinheim reconstructio was also fairly close in several of the cranial analyses, but the classic Neanderthals were distant and forms such as Petralona and Rhodesian even appeared morphologically closer to Skhūl 5 in one analysis (analysis 8). The differences

from the Neanderthals were in many cases those which distinguished the modern populations from the Neanderthals, and included the smaller supraorbital projection, longer higher parietal, the shorter narrower skull dimensions and higher frontal bone with a wider bifrontal chord. Compared with Pekin the differences also included the more modern occipital (longer with a higher lambda-subtense fraction), higher vertex radius and reduced biauricular breadth. However Skhūl 5 still differed significantly from the Upper Palaeolithic population in possessing a shorter but lower frontal bone with wide bifrontal chord, a greater cranial and biasterionic breadth, and a lower vertex radius, but differed less from other forms such as Hotu.

In the features of the face Skhūl 5 was less modern than in the features of the cranium, but the differences were not necessarily in the direction of the Neanderthals. The large palate and face, broad nose and bigger supra-orbital projection were resemblances to earlier populations. But the breadth of the upper face, relatively narrow nose compared with the classic Neanderthals, deeply set nasion (giving low values of the nasio-frontal subtense, nasion radius and nasio-occipital length) and the relatively lower values of the zygoorbitale, M1-alveolus and subspinale radii were resemblances to the non-classic Neanderthals especially Djebel Irhoud. Some of these characteristics must be treated with caution on account of the extensive reconstruction of the face, but they were consistent enough with those of the early and Middle-East Neanderthals, Cohuna and Djebel Irhoud to suggest that they were essentially correct. Graph plots (e.g. Figure 5) confirmed that Skhūl 5 was still

not totally modern in such features as the prosthion angle (NA-BA), but other angles (Figures 4, 6) did differentiate Skhūl 5 from early groups and aligned it with the Upper Palaeolithic and recent populations.

Upper Palaeolithic (see Table 16)

Cranially the Upper Palaeolithic population was closely linked with Hotu, the Mesolithic group and recent populations, Skhūl 5, Omo 1, Iwo Eleru and to a lesser extent Omo 2. The most distant groups on cranial measurements alone were forms such as Pekin, Rhodesian and Petralona. The cranial characteristics which grouped all the "modern" forms together so closely included the low supraorbital projection and the short high but narrow skull with an especially long parietal chord and high bregma subtense. Facially the differences between populations such as the Neanderthals and the Upper Palaeolithics were even greater, and as has been described already they centred on the distinctiveness of the Neanderthal middle face, especially the long projecting nasal region. There seems good evidence from the analyses that non-classic Neanderthals were closer, particularly in facial characteristics, to the Upper Palaeolithic group. Furthermore the generally large D^2 distances of Petralona (see Table 15), Rhodesian and Steinheim from the recent groups emphasised their general distinctiveness, but nevertheless they fell closer to the Upper Palaeolithics than did the Neanderthals in some facial analyses and angle plots.

Trends since the Upper Palaeolithic in reduction of cranial size can be confirmed by the comparisons of Upper Palaeolithic, Mesolithic and the recent reference populations. The upper face was reduced in breadth, and

Analysis	6	7	8	9	10	11	12	13	14
No. of vars.	15	13	17	9	8	9	11	25	25
Area	vault	vault	vault	radii	face	face	face	skull	skull
Crania									
Maximum value of any recent population	7.83 (110)	8.79 (102)	9.49 (110)	9.81 (86)	12.19 (108)	12.95 (108)	14.01 (107)	32.30 (99)	20.28 (102)
Skhūl 5	N.S.	15.27	17.67	21.76	20.55	N.S.	19.43	43.13	41.55
Omo 1	18.56	-	-	-	-	-	-	-	-
Omo 2	48.67	32.35	48.95	-	-	-	-	-	-
Saccopastore 1 and 2	51.14	-	-	21.95	15.27 (2)	18.78 (2)	-	-	95.33
Djebel Irhoud 1	67.89	61.97	68.39	32.94	44.58	49.01	35.38	99.58	121.73
Amud/Tabūn	-	46.74 (2)	-	22.02	45.47	51.21	61.63	109.5	97.73
Neanderthal	76.51 (3)	55.47 (8)	82.53 (3)	48.76 (4)	51.40 (4)	54.05 (4)	63.1 (4)	134.4 (2)	127.38 (4)

Samples are of single specimens except where indicated by bracketed figures. Values are corrected for differences in sample size and are significant at the 5% level except where marked N.S.

TABLE 16 Generalised distances (D^2) of crania from the Upper Palaeolithic group

there was a similar reduction apparent in cranial length and height, biauricular breadth, parietal chord and supra-orbital projection (except in the Tasmanians). Nasal height and facial size seemed smaller in the reference populations, whilst nasal breadth was greater in the Upper Palaeolithics than in the Eskimoes, less than in the Tasmanians and Zulus and about the same as in the Norse group. Mastoid process size was generally similar although those of the Upper Palaeolithic peoples were thicker. The zygomaxillary and frontomalare radii were higher in the Upper Palaeolithics than in the reference populations, except for the Eskimoes who possessed similarly flat faces.

Compared to the Mesolithic group, which was hardly differentiated throughout the analyses, there were minor differences as outlined above but in other dimensions (vertex radius, cheek height, glabellar projection and palate breadth) they appeared to be less robust than the Mesolithic group, which included the strongly-built North African material. In general, as also found by van Vark (1970), the recent reference populations were equally distinct from the Upper Palaeolithics, whereas the Mesolithic crania were substantially closer to the Upper Palaeolithic group.

Of the other individual specimens included in analyses, the Hotu skull was confirmed as an anatomically modern specimen closest in morphology as well as date to the Mesolithic group. The Podkumok frontal bone, dubiously associated with a Mousterian industry was, from the evidenc of Analysis 1, generally closest to the Upper Palaeolithic and modern populations. This suggested that it was probably an intrusive burial into a Mousterian horizon.

(ii) Ancestral characteristics of early Homo sapiens populations

Comparing the chronologically earliest samples used in these analyses it is possible to construct a list of features in common which may be regarded as ancestral characteristics for all later Homo sapiens populations. The Pekin and Petralona crania were long and low, although some later fossils showed an even greater glabella-occipital length. They were broad at the base (especially in biauricular breadth), a feature which was in turn correlated with a large bizygomatic breadth and bicondylar width of the mandible.

Cranially the frontal bone was long but with a high frontal subtense fraction and low values of nasion subtense, bistephanic breadth and bifrontal chord. The supraorbital projection was large although exceeded by the values found in some later populations. Compared with recent man the parietals were short and low, although Petralona was morphologically already close to Neanderthal man, whereas the Pekin skulls were closer to the single example of Homo erectus from Java included in the parietal analysis. Both forms displayed a short occipital chord with a high occipital subtense and biasterionic breadth. But the morphology of the Petralona occipital was more advanced than that of Pekin with an apparently reduced occipital torus and nuchal angulation, albeit still more marked than in all later European forms.

The breadth of the upper face of the Pekin crania would have been large compared to modern man, but small compared to Petralona and various other crania in the

analyses. If Petralona represented the ancestral population of later European fossil men, then facially that population was much more robust than the fragmentary Pekin material indicated, even allowing for possible factors of sexual dimorphism. Petralona displayed a face which was absolutely large in most dimensions, but particularly massive in the breadth of the upper face, cheek height and palate breadth. The orbits were not as large as in some later forms and were enclosed by massive surrounding areas of bone. The nasal region was not large by Neanderthal standards and there were features of facial projection indicating differences from classic Neanderthal morphology. Although the lower face was certainly projecting, the middle face was relatively flat and lay below a deeply-set nasion.

In assessing the likely phylogenetic status of the Pekin and Petralona material it is wise to remember the limited material available from this time level. But on the available evidence, the Pekin material was cranially less "advanced" than the Petralona skull in parietal and occipital morphology, but was apparently more "advanced" in the form of the frontal bone and face. This presents more evidence of the operation of "mosaic" evolution in human populations, and supports the idea that, cranially at least, European populations were evolving more rapidly than those known from other areas at this time. This idea has already been postulated in connection with the material from Vértesszöllös, Steinheim and Swanscombe (e.g. Howell, 1960; Thoma, 1969) and Petralona (Kurtén, 1972). The fact that the Rhodesian and Solo material is of much later date than Petralona but was of a similar morphology in some respects, also tends to confirm this idea. However the massive facial morphology of the recently discovered

"Pithecanthropus VIII" (Sartono, 1971) skull is reminiscent of Petralona as far as can be judged from illustrations (Figures 51, 52). Hence Petralona may display a facial morphology lost in the chronologically later Pekin material.

When calculating evolutionary rates of change for Pleistocene human populations Bilsborough (1971) used Pekin as the model of an early Middle Pleistocene population and compared it to later European fossils such as Steinheim and Swanscombe. However there is no evidence that the Pekin population could have been ancestral to those of Europe and it seems likely that rates of change for cranial and facial complexes would differ considerably if based on the Petralona skull as an alternative Middle Pleistocene model. The transition from Homo erectus to Homo sapiens probably occurred at different times in various areas, and around the Mediterranean it may have occurred earlier than in peripheral areas such as Southern Africa and the Far East. On cranial evidence the present author considers that Petralona was an early Homo sapiens skull, equivalent morphologically to the Rhodesian skull and Solo material, but by no means identical to them in all features. The Pekin material cranially was more primitive than these early sapiens forms but given more complete facial material from Pekin it might be more difficult to deny the Choukoutien remains status as Homo sapiens.

(iii) Concluding remarks: Human evolution during the Middle and Upper Pleistocene (see Figure 54)

In the introduction to this thesis, various theories of human evolution were described ranging from those which gave the Neanderthals no place in the evolution of modern man to those which saw "Neanderthals" evolving into modern man all over the Old World. Using the results of the analyses conducted here it is possible to comment further on these various evolutionary schemes.

(a) The "pre-sapiens" schemes

First there would seem to be no evidence of the appearance of anatomically modern man in the Middle Pleistocene. The fossils from Vértesszöllös, Swanscombe and Steinheim appear to be closely related to each other and to the succeeding Riss-Würm European populations. Their morphology was not necessarily representative of populations elsewhere in the world, and cranial evolution appears to have been particularly rapid during the Middle Pleistocene of Europe, and slower subsequently. Facial evolution appears to have been slower in Europe, although the Steinheim skull was comparatively gracile, but not modern, in morphology. The great morphological distance between Petralona and the Neanderthals when large numbers of variables were used indicates the morphological change which occurred over the half million years which separated these apparently related populations. But the Europeans of the Middle and early Upper Pleistocene seem to represent one evolving lineage from Petralona, Vértesszöllös, Steinheim, Swanscombe and the early Neanderthals (including Fontéchevade) to the "classic" forms. Neither is it possibl

to represent this line as one divorced from other populations around the Mediterranean (de Lumley and de Lumley, 1971). The new Arago material is morphologically similar to the "Atlanthropus" mandibles from Algeria (Stringer, unpublished study), and fossils such as Djebel Irhoud and the Middle-East Neanderthals were clearly related to the European material. Thus the "pre-sapiens" theory of Boule and Vallois (Boule, 1923; Vallois, 1954) cannot be substantiated, and the similar views held by the late Dr. L.S.B. Leakey (1953) of a separate line leading from Homo habilis to modern Homo sapiens are not supported by the fossil evidence available.

(b) Unilinear or polyphyletic schemes

At the other extreme, the strongly-revived ideas of Hrdlička and Weidenreich (Hrdlička, 1927, 1930; Weidenreich, 1949; Coon, 1963; Brace, 1964; Brose and Wolpoff, 1971) postulating evolutionary lines in various areas leading from "Neanderthaloid" forms to modern man cannot be supported either. Modern populations and those of the Upper Palaeolithic and Mesolithic form a tightly-knit group compared to the diversity of the "Neanderthaloids" from Europe, Africa and the Far East, and a remarkable degree of convergence would be required to produce such similar modern forms from such a heterogeneous group. The classic Neanderthals of Europe are separated from the succeeding Upper Palaeolithic population by inordinately large generalised distances for the short space of time available for an evolutionary transition from Neanderthal to modern man in Europe. In fact the D^2 distances involved are in most cases larger than those which separate the Neanderthals from more recent

populations as also observed in the hand bones of these populations (Musgrave, 1970). Moreover certain morphological features of the "classic" Neanderthals were not present in known earlier populations which resemble modern man more closely and these features appear to be specialisations which contrast markedly with the morphology of the Upper Palaeolithic population.

The reasons behind these morphological specialisations are unknown but some, especially those of the face, could be adaptations to life in glaciated conditions as Coon (1963) and others have suggested. The fact that these features of facial morphology are not like those of the modern Eskimo can be accounted for, partly at least, by the fact that the morphology of the "classic" Neanderthals was developed from an early Homo sapiens morphology, whereas that of the Eskimoes is presumably superimposed on a basic modern Homo sapiens pattern. Additionally the environments of the modern Eskimo and that of the Würm Neanderthals probably differed in terms of humidity as well as temperature, and the less sophisticated Neanderthal cultural equipment would have rendered them liable to a relatively intense selection by the environment.

There is also strong evidence that the post-cranial remains of the Neanderthals were similarly distinct from modern populations. Although the anatomical characteristics of the La Chapelle skeleton were originally wrongly interpreted in several cases (Straus and Cave, 1957), more recent work has confirmed that the classic Neanderthals were distinctive in hand morphology (Musgrave, 1971, 1973) and in the morphology of the scapula (Stewart,

1962b). The Middle-Eastern Neanderthal post-cranial material is less distinct from modern man but still shows much in common with the European classic Neanderthals (Stewart, 1960, 1962a, 1962b; Endo and Kimura, 1970). A study of the new post-cranial material from such sites as Regordou, Hortus and Arago, as well as a reassessment of the Krapina material, is necessary to clarify the evolutionary development of the Neanderthal skeleton, but at the moment it seems that the early Neanderthals were less different from modern man than the classic forms, as is also indicated by cranial studies.

To return to the Würm Neanderthals of Europe, their replacement by Upper Palaeolithic man seems to have been rapid, although archaeological evidence is ambiguous on this point. One late Mousterian industry, the Mousterian of Acheulean tradition, may have directly evolved into the Perigordian (Châtelperronian) of the Upper Palaeolithic (Bordes, 1961, 1968, 1972; Mellars, 1971). However no human remains associated with the Mousterian of Acheulean tradition are known, and little material is certainly associated with the Perigordian, with the possible exception of Combe Capelle, which is not "Neanderthaloid" in appearance. It is conceivable that men of modern form were coexisting alongside the Neanderthals in Europe and produced the particular Mousterian industry which led to the Perigordian. However it is more likely on the evidence available that there was culture contact between the Mousterian and Upper Palaeolithic populations, especially as the two cultural groups are now thought to overlap in time to some extent (Oakley, 1969; Bordes, 1971).

That this was not accompanied by large-scale population interbreeding is evident from the physical characteristics of the earliest Upper Palaeolithic skeletal material which is consistently of an anatomically modern, albeit robust, type. Additionally the other Upper Palaeolithic industry contemporary with the Perigordian - the Aurignacian - seems to have arrived fully developed in Europe at an earlier date, perhaps over 40,000 years ago (Oakley, 1969; McBurney, personal communication, 1973), and can be traced back to the Middle-East in increasingly ancient carbon-14 dates (McBurney, personal communication, 1973). Its arrival would appear to coincide with two short interstadial phases in which more temperate conditions could have brought a new fauna into Europe for a brief period, and with it new human populations from the Near and Middle-East. Thus even if the Neanderthals evolved culturally, they did not appear to undergo a parallel physical evolution into modern man, but were probably at a disadvantage, culturally and physically, during the unstable but temperate Würm II/Würm III (in the French and Netherlands usage) transition. Hence economic competition from the Upper Palaeolithic populations, rather than tribal warfare, probably led to the demise of the Neanderthal population which may already have been depleted by the severe climatic conditions of Würm I.

Morphologically, culturally and genetically, then, the Upper Palaeolithic population was distinct from the Neanderthals and its origins probably lay outside Western Europe. Some anthropologists (e.g. Hemmer, 1972a; Watanabe, 1972) favoured colder areas such as the sub-arctic forest zones or steppe and tundra zones as the place of

origin of modern Homo sapiens, but there is no fossil evidence to support this idea. Instead, the earliest evidence of a near-modern morphology is that of Skhūl, Qafza and Omo from the Middle-East and North-East Africa, generally associated with Levalloiso-Mousterian industries. Thus the physical transition from early Homo sapiens to modern Homo sapiens may have occurred before the cultural change leading to the Upper Palaeolithic and cannot be seen as a consequence of this change. These early modern groups may also have extended across North Africa and into Western Asia and India but at present there is no evidence of this.

The Middle-Eastern Neanderthals must represent a group which evolved out of an early Neanderthal stock and which may have been in intermittent genetic contact with the "classic" Neanderthals of Europe during the early Würm. They would thus have built up a gene pool containing "classic" Neanderthal features, provided these were being positively selected for in Europe and were selectively neutral in the Middle-East(Brues, 1972). This would explain the cranial and facial morphology of the Amud 1 skull (and of Shanidar and the less complete Tabūn 1 skull) which was less specialised than the European Neanderthals in some respects, but was certainly not of modern form. The evolution of the Middle-East Neanderthal population from a widespread "early sapiens" group could also explain the surprising links between Amud and the Rhodesian skull, and between Amud and Djebel Irhoud. However Amud and Tabūn were still very distant in terms of the generalised distance statistic from both the Skhūl 5, Omo and Upper Palaeolithic groups and yet Amud is one of

the latest Neanderthals known (35,000-40,000 years B.P.: Suzuki, 1970) and according to Brace and others is "modern" (Brace et al, 1971; Brose and Wolpoff, 1971). Thoma (1972) has viewed Amud as an ancestor for the Palaeosiberians and the Mongoloid peoples. This too was not supported by the great generalised distances between Amud and the Eskimo population. Amud 1 displayed an unusual form of the pubic bone also found in the Shanidar and Tabūn pelves but not found in the Skhūl or Upper Palaeolithic material (Stewart, 1960; Endo and Kimura, 1970) which only seemed to heighten the contrasts between the populations. Furthermore this unusual pubic structure has been observed in the La Ferrassie I pelvic fragments and hence may have been widespread in the Neanderthals (E. Trinkaus, personal communication, 1973).

In areas outside Europe and the Middle-East the situation was more complex, the dating of the fossils less certain. If the Solo and Rhodesian populations were more ancient than the Upper Pleistocene then they might be accommodated into an evolutionary scheme leading from them to certain later forms of man. The fact that the Rhodesian skull was closest in overall form to Petralona of all crania included in the analyses suggests that it preserved a morphology similar to early middle Pleistocene populations in Europe. But unless the antiquity of the Broken Hill skull is even greater than Klein (1973) has suggested, it is an unlikely ancestor for modern man. There is no evidence from the generalised distances of any particular affinity between Rhodesian man and the modern Zulu, which would be expected if Coon's polyphyletic scheme is correct (Coon, 1963). In fact facially, where the

resemblances might be expected to particularly manifest themselves, the Tasmanian, Norse, Upper Palaeolithic and Mesolithic populations were all closer in various analyses to the Rhodesian skull. The same can be said of the Saldanha skull where it could be included in the analyses (for example analysis 4). It was certainly of more "modern" morphology than the Rhodesian cranium but nevertheless resembled the Zulu population least of all.

Study of the generalised distances of the Pekin crania similarly provided absolutely no support for an evolutionary scheme linking them with the Mongoloid populations rather than with any other modern groups. Obviously great morphological changes would have had to occur to convert an Homo erectus morphology into one like that of the modern Eskimo but nevertheless it is interesting that the Eskimoes are consistently furthest of all populations from the Pekin material. This is very surprising if there is a closer phyletic relationship between them than between Pekin and other later populations.

The Cohuna skull, although certainly more archaic than any recent or Upper Palaeolithic populations, likewise does not provide support for the polyphyletic evolutionary scheme. Weidenreich's scheme (Weidenreich, 1943b) linked the Solo material to the modern Australian aborigines via Cohuna, but this evolutionary sequence was not sustained by the results of multivariate analyses. Cohuna, particularly in the form of the frontal bone, was not close to the recent Tasmanians (which in Howell's study of 1973 were morphologically close to modern Australian aborigines). But equally the unusual form of the frontal bone was not particularly close to the Solo

population either. Furthermore the Solo population was morphologically less distant from the Upper Palaeolithic and Norse groups than from the Tasmanians, whilst Cohuna was not distant from the Tasmanians in facial and parietal form. Cohuna was thus an unlikely descendent of the Solo population but was, ignoring the anomalous frontal bone, a possible ancestral form for later Australian peoples. The relationships of Cohuna and the Kow Swamp material to the Mungo material are not at present known, but the arrival of man in Australia seems certain to have occurred before 30,000 years B.P. and populations moving down the South-East Asian area into Australasia may have "absorbed" some more archaic population genes on the way.

Thus the Solo and Rhodesian populations cannot meaningfully be called "Neanderthals", and neither can they be linked with recent populations unless their dating is substantially altered, or unless they were genetically "absorbed" into more modern groups. However the Omo 2 and Iwo Eleru material demonstrate that some later Pleistocene crania did show morphologies somewhat similar to the Solo and Rhodesian forms. Whether this indicates any evolutionary relationship is unlikely because of the relative dating of these crania. But it is possible that Africa contained a population spectrum from "Rhodesioids" in the South to more modern forms in the North and that when these more modern populations subsequently spread across Africa they "absorbed" the more archaic varieties. This would explain why the Iwo Eleru skull was of basically modern form but with some elements of resemblance to more archaic populations, and would also account for the robustness of early South African material such as

Florisbad. Even so this "absorption" of genes from forms such as Rhodesian man cannot be equated with an evolutionary relationship between Rhodesian and modern man, since the founder population (Omo, Iwo Eleru, Kanjera?) and the latest populations (e.g. Zulu?) were more closely related to each other morphologically than either was to the Rhodesian group. The same can be said of early Australian material (e.g. Mungo: see Bowler, Thorne and Polach, 1972) which, although archaic, showed little morphological sign of the absorption of genes from the Solo populations.

Thus the unilinear schemes of Hrdlička (1927, 1930), Brace (1964) and others, and the similar polyphyletic schemes of Weidenreich (1949), Coon (1963) and, more recently, Thoma (1972) cannot be supported by the results of analyses performed here. These have repeatedly shown how homogeneous are the recent comparative material (Norse, Zulu, Tasmanian and Eskimo) and the Upper Palaeolithic and Mesolithic populations, in great contrast to the diversity of the Homo erectus and early Homo sapiens material. This confirmed that truly modern man was of relatively recent origin, and that "racial" differences were in many ways superficial developments on a basic modern morphology rather than the results of half a million years of relatively independent evolution in geographically separate areas.

(c) The "pre-Neanderthal" theory

The "pre-Neanderthal" theory, which derives modern Homo sapiens from a varied early Neanderthal group which also gave rise to the "classic" Neanderthals of Europe is supported by some of the results of the analyses.

Facially (and probably post-cranially) the early Neanderthals are less specialised than the later forms and cranially they are somewhat closer to early modern forms such as Skhūl 5 and Omo 1, and possible ancestral types such as Omo 2. But if the Omo and Qafza remains are accepted as being contemporary with the early Neanderthals, then they represent more plausible ancestors for modern man. However it is possible that they themselves may have sprung from a "Neanderthaloid" morphology similar to that exhibited by the Djebel Irhoud skull which is however of an apparently later date. The Djebel Irhoud skull is considered by some as a likely ancestor for the North African Upper Palaeolithic/Mesolithic populations (Brace et al, 1971; Ferembach, 1972) but after a long Middle Palaeolithic phase in the area the Aterian industry disappears and is apparently suddenly replaced by the Iberomaurusian associated with the remains from Taforalt and other material of robust but modern morphology. The relative isolation of the Atlas massif beyond 600 miles of desert could have led to the survival of forms like Djebel Irhoud and the "mousteroid" Aterian industry long after equivalent populations and industries had been replaced elsewhere by modern forms with late Palaeolithic traditions (McBurney, 1972).

(d) <u>The "Spectrum Hypothesis"</u>

The spectrum hypothesis provides the best explanation of the results of these analyses since it is extremely difficult to provide a simple classification of the fossil material beyond separating the characteristics of <u>Homo erectus</u> from those of <u>Homo sapiens</u> and distinguishing non-modern morphologies from modern. It is possible

to visualise the evolution of early Homo sapiens forms from already varied Homo erectus populations during the late Lower or Middle Pleistocene. This transformation may have occurred in Europe at a relatively early date, the Heidelberg, Petralona and Vértesszöllös remains representing the earliest examples. However these forms do not necessarily have to be directly ancestral to modern Homo sapiens since they also represent potentially good ancestors for the later European Neanderthals. Equivalent transitional forms from Homo erectus to Homo sapiens existed at a later date in Africa (Rhodesian man) and the Far East (Solo), but these are not classic Neanderthal forms and appear to be less specialised.

Within a broadly contemporary group around the Mediterranean there was a spectrum of Neanderthal characteristics from the classic Neanderthals of Europe to Amud and Tabūn and finally to Djebel Irhoud which represents a geographical distance of four thousand miles allowing for no population contact across the Mediterranean. This spectrum may be extended to include the Skhūl population as the least "Neanderthaloid" member, especially since it shows affinities to the Djebel Irhoud skull. But these crania are still contrasted in their affinities to the modern and Neanderthal groups with Djebel Irhoud clearly lying with the Neanderthals as a whole, and Skhūl 5 showing much greater resemblances to the Upper Palaeolithic and Mesolithic populations. Similarly the Omo material is not Neanderthal in morphology, despite the archaic features of Omo 2, and can hardly be included in the Neanderthal spectrum. The Qafza remains, which were unfortunately not accessible to the present author, are

also clearly not Neanderthal in any meaningful sense of the word despite their cultural associations and early date (Vandermeersch, 1972; Vallois and Vandermeersch, 1972).

Thus another spectrum can be envisaged developing out of the early sapiens forms, ranging down Africa from the Omo 1 and 2 morphology to the more "primitive" Rhodesian types in Southern Africa. A similar spectrum may also have existed across Asia but there is no fossil evidence from these areas at present, except from Mapa in China (Coon, 1963; Howells, 1967). It is imperative that efforts are made to find such material in the future since this would greatly clarify the present picture, erected primarily around the European and Middle-Eastern material which may well be completely unrepresentative of populations elsewhere. The evidence from the Far East of the early arrival of modern men in Borneo (the Niah Cave: Brothwell, 1960) and in Australia (Mungo: Bowler, Thorne and Polach, 1972) shows that modern populations had already appeared in the Far East when Neanderthals were still living in Western Europe and the Middle-East. Whether such early modern forms had developed locally or had migrated from an area further West or North is unknown, but these forms could plausibly represent descendents of populations like those of Omo and Qafza present at an earlier date further West.

(iv) Definitions of the term "Neanderthal".

Previous attempts to define this term have been based on metric or morphological characteristics (Morant, 1927; Le Gros Clark, 1966: 60-62), cultural factors (Hrdlička, 1930: 328), temporal factors (Brose and Wolpoff, 1971: 1156) or combinations of these criteria (Brace, 1964: 18). Any definition based solely on cultural data must certainly be inadequate if Qafza has to be included in the group (Vandermeersch, 1972), as discussed earlier. A purely temporal definition is insufficient when applied to the period from the end of the Riss to the emergence of modern man (Brose and Wolpoff, 1971) since if we accept that the Qafza remains represent "modern man" and are early Würm (Farrand, 1972), then many European classic Neanderthal specimens may well post-date these remains and are hence excluded from the definition. Additionally this temporally-defined group would encompass such an inordinately large range of morphologies as to be virtually meaningless, or equivalent only to a term such as "early Homo sapiens".

The present author has not had the opportunity to undertake a full morphological study of all the Neanderthal specimens and hence cannot comment in detail on the definition provided by Le Gros Clark (1966). It is certainly possible to dispute points in his morphological definition since the present author has not observed a strong occipital torus nor the lack of a chin eminence in every Neanderthal specimen examined, and the quoted range of cranial capacity for the group is certainly too low (Suzuki, 1970). Nevertheless the descriptions provided by Morant (1927), Hrdlička (1930)

and Le Gros Clark (1966) seem to represent more practical approaches to the problem than definitions employing temporal or cultural factors alone. The results and discussion of this thesis have, it is hoped, provided some additional characteristics which can be placed alongside those provided by authorities such as Morant (1927), Hrdlička (1930) and Le Gros Clark (1966).

Furthermore, the results of this thesis have confirmed that the European Neanderthal forms of the Würm did display features, particularly of the face, which were distinct from other populations in the analyses. Thus it would seem useful to maintain the term "classic" for such specimens. These facial characteristics, which may have been due to cold adaptation (Coon, 1963; Brose and Wolpoff, 1971; Steegman, 1972) might also be expected to be present in contemporary groups elsewhere such as the Middle-East Neanderthals (Brues, 1972), but would not be expected in the early Neanderthals from Europe unless they were the result of even more ancient adaptation to a cold environment. The fact that both the early and the Middle-East forms do share certain characteristics with the classic Neanderthals suggests that some facial features were functional rather than climatic adaptations, perhaps giving some mechanical advantage to the anterior dentition (Howells, unpublished) and yet others may have been present in a common ancestral population.

Thus three closely related types of Neanderthal can be recognised morphologically: early, Middle-Eastern and classic, mainly limited to the Mediterranean and peripheral regions but extending at least into Western Asia. Culturally they were associated mainly with

Mousterian or Levalloiso-Mousterian industries, but there is no reason to suppose that this was an absolute association. As more modern forms of man produced Mousterian industries (Vandermeersch, 1972), so the Neanderthals might be associated with earlier tool traditions or could even have acquired elements of "Upper Palaeolithic" technology by independent invention or diffusion. Temporally the group can be demarcated on present evidence using the European Riss-Würm as the earliest, and the Würm II/III interstadial (French and Netherlands usage) as the latest limit. Eventually absolute dating may fix these chronologies more exactly, and allow complete correlations between European and other Pleistocene deposits, whilst study of new fossil material such as Arago (from the Riss) will demonstrate whether temporal boundaries provide workable definitions of "Neanderthal".

Problematical specimens which are difficult to place in rigid categories are to be expected if the spectrum hypothesis represents an adequate model of Pleistocene human evolution. Djebel Irhoud, Broken Hill, Solo, Skhūl and Omo are examples of specimens which have been called "Neanderthaloid" but they certainly cover a wider geographical area and probably also a greater temporal range than that already suggested for the true Neanderthals. It is more satisfactory to avoid classifying them at the moment, beyond stating that they represent sub-specific varieties of Homo sapiens, displaying non-modern morphologies (except for Skhūl and Omo 1) and a complex pattern of varying degrees of resemblance to the Neanderthals proper, to modern man and

to each other. The early, classic and Middle-Eastern Neanderthals were not identical forms and, on the limited evidence available, were certainly at least as varied cranially as any two modern "races" of man. In the opinion of the present author it will become increasingly difficult to define terms such as "Neanderthal", "Homo erectus" and "Homo sapiens" as more fossil evidence accumulates, but this situation should be welcomed by students of human evolution. For the moment however, it seems misleading and pointless to apply the term "Neanderthal" to a world-wide range of fossil men of varying morphology in order to "prove" that modern man evolved from the Neanderthals.

Summary

Various proposed models of Pleistocene human evolution were investigated by a multivariate study of the available fossil cranial material from the Middle and Upper Pleistocene, primarily employing the Mahanolobis generalised distance (D^2) statistic applied to measurements of areas of the skull. In general the results of analyses did not support the proposed existence of "pre-sapiens" lines in the Middle Pleistocene, but equally the unilinear and polyphyletic schemes which postulate direct evolution from Neanderthal to modern man were shown to be similarly inadequate. The generalised distances between Neanderthal and succeeding populations were inordinately large considering the short period of time for such a morphological transition, and the Upper Palaeolithic and recent populations formed an extremely compact group compared to the diversity of the fossil forms.

Certain morphological features of the classic Neanderthals were not present in known earlier populations which instead showed greater resemblances to modern man. It seems likely that there was a fairly widespread form of early Homo sapiens present around the Mediterranean during the Middle Pleistocene. In the North this group eventually gave rise to the classic Neanderthals of the Upper Pleistocene, whose morphology could in part be a result of adaption to the European Würm environment. A "cline" of decreasingly classic Neanderthal features was discernible in contemporary crania from Europe to the Middle-East and North Africa. Outside these areas, however, fossils such as Broken Hill and Solo demonstrated

that populations in Southern Africa and Asia could not meaningfully be classed as "Neanderthals" since they showed different blends of Homo erectus and Homo sapiens characteristics. Other non-Neanderthal populations, apparently earlier than or contemporary with Neanderthal man, were also in existence in Ethiopia and the Middle-East. These fossils represented the most likely ancestors known for modern man, although in certain areas the replacement of archaic populations by more modern forms was probably only gradual.

Another result of this study was a reassessment of the uncertainly dated Petralona skull which did not resemble the Neanderthals or more modern man in a number of metrical and morphological characters. Instead it seemed to represent an early stage in the evolution of Homo sapiens from Homo erectus, and may be the oldest cranium of our own species so far discovered.

REFERENCES.

ANONYMOUS (1972). Late Pleistocene man at Kow Swamp. Editorial comment from a correspondent. Nature, Lond., 238: 308.

ARAMBOURG, C. (1958). Les stades évolutifs de l'humanité. In: The Leech (Raymond A. Dart commemorative number). 28: 106-111.

BALOUT, L. (1965). Le Moustérien du Maghreb. Quaternaria, 7: 47.

BARTLETT, M.S. (1965). Multivariate statistics. In: Theoretical and Mathematical Biology, chap. 8: 201-224. Ed. T.H. Waterman and H.J. Morowitz. New York: Blaisdell.

BIBERSON, P. (1964). La place des hommes du Paléolithique Marocain dans la chronologie du Pléistocène Atlantique. Anthropologie, Paris, 68: 475-526.

BILSBOROUGH, A. (1971). A comparative study of evolutionary rates in Hominoids. Ph.D. Thesis. Oxford.

BILSBOROUGH, A. (1972). Cranial morphology of Neanderthal man. Nature, Lond., 237: 351-352.

BORDES, F. (1958). Le passage du Paléolithique moyen au Paléolithique supérieur. In: Hundert Jahre Neanderthaler. Ed. G.H.R. von Koenigswald. Utrecht: Kemink en Zoon.N.V.

BORDES, F. (1961). Mousterian cultures in France. Science, N.Y., 134: 803-810.

BORDES, F. (1968). The Old Stone Age. London: Weidenfeld and Nicholson.

BORDES, F. (1971). Physical evolution and technological evolution in man: a parallelism. World Archaeol., 3: 229-254.

BORDES, F. (1972). Du Paléolithique moyen au Paléolithique supérieur: continuité ou discontinuité? In: The origin of Homo sapiens. Proceedings of the Paris symposium, September 1969, organised by Unesco in co-operation with the International Union for Quaternary Research (INQUA). Ed. F. Bordes. Paris: Unesco.

BOSTANCI, E. (1964). An examination of a Neanderthal type fossil skull found in the Chalcidique Peninsula. Türk. Tarîh Kurumu Basimenî, Belleten, 28: 377-381.

BOULE, M. (1911-1913). L'homme fossile de La Chapelle-aux-Saints. Annls. Paléont., 6, 7, 8.

BOULE, M. (1923). Les hommes fossiles: éléments de paléontologie humaine. Paris: Masson et Cie.

BOWLER, J.M., THORNE, A.G. & POLACH, H.A. (1972). Pleistocene man in Australia: age and significance of the Mungo skeleton. Nature, Lond., 240: 48-50.

BRACE, C.L. (1962a). Cultural factors in the evolution of the human dentition. In: Culture and the evolution of men. Ed. M.F.A. Montagu. New York: Oxford University Press.

BRACE, C.L. (1962b). Refocusing on the Neanderthal problem. Am. Anthrop., 64: 729-741.

BRACE, C.L. (1963). Structural reduction in evolution. Am. Nat., 97: 39-49.

BRACE, C.L. (1964). The fate of the "Classic" Neanderthals: a consideration of hominid catastrophism. Curr. Anthrop., 5: 3-43.

BRACE, C.L. (1967). The stages of human evolution: human and cultural origins. Englewood Cliffs, N.J.: Prentice-Hall.

BRACE, C.L., NELSON, H. & KORN, N. (1971). Atlas of fossil man. New York: Holt, Rinehart and Winston.

BREITINGER, E. (1957). On the phyletic evolution of Homo sapiens. Reprinted in: Ideas on Human Evolution. 1962. Ed. W.W. Howells. Cambridge: Harvard University Press.

BREITINGER, E. (1964). Reconstruction of the Swanscombe skull. In: The Swanscombe Skull. A survey of research on a Pleistocene site. Ed. C.D. Ovey. London: Royal Anthropological Institute.

BROSE, D.S. & WOLPOFF, M.H. (1971). Early Upper Paleolithic man and late Middle Paleolithic tools. Am. Anthrop., 73; 1156-1194.

BROTHWELL, D.R. (1960). Upper Pleistocene human skull from Niah Caves. Sarawak Mus. J., 9: 323-349.

BROTHWELL, D.R. (1961). The people of Mount Carmel - a reconsideration of their position in human evolution. Proc. prehist. Soc., 27: 155-159.

BROTHWELL, D.R. & SHAW, T. (1971). A late Upper Pleistocene proto-West African negro from Nigeria. Man., 6: 221-227.

BRUES, A.M. (1972). Models of race and clime. Am. J. phys. Anthrop., 37: 389-400.

BUTZER, K.W. (1969). Geological interpretation of two Pleistocene hominid sites in the Lower Omo Basin. Nature, Lond., 222: 1133-1135.

CAMPBELL, B.G. (1964). Quantitative taxonomy and human evolution. In: Classification and human evolution. Ed. S.L. Washburn. London: Methuen.

CLARK, W.E. Le Gros (1966). The fossil evidence for human evolution. Chicago: University of Chicago Press.

COON, C.S. (1963). The origin of races. London: Jonathan Cape.

CRICHTON, J.M. (1966). A multiple discriminant analysis of Egyptian and African Negro crania. Papers of the Peabody Museum, Harvard University, 57: 45-67.

DAY, M.H. (1967). Olduvai hominid 10: a multivariate analysis. Nature, Lond., 215: 323-324.

DAY, M.H. (1969). Omo human skeletal remains. Nature, Lond., 222: 1135-1138.

DAY, M.H. (1972). The Omo human skeletal remains. In: The origin of Homo sapiens. Proceedings of the Paris symposium, September 1969, organised by Unesco in co-operation with the International Union for Quaternary Research (INQUA). Ed. F. Bordes. Paris: Unesco.

DAY, M.H. (1973). The development of Homo sapiens. Atti del Colloquio Internazionale sul tema: L'Origine dell'Uomo. October 1971. Roma: Accademia Nazionale dei Lincei., 182: 87-95.

DAY, M.H. & WOOD, B.A. (1968). Functional affinities of the Olduvai hominid 8 talus. Man, 3: 440-455.

DAY, M.H. & WOOD, B.A. (1969). Hominoid tali from East Africa. Nature, Lond., 222: 591-592.

DOBZHANSKY, T. (1944). On species and races of living and fossil man. Am. J. phys. Anthrop., 2: 251-256.

DOBZHANSKY, T. (1964). Genetic entities in hominid evolution. In: Classification and Human Evolution. Ed. S.L. Washburn. London: Methuen.

ENDO, B. & KIMURA, T. (1970). Post-cranial skeleton of the Amud man. In: The Amud man and his cave site. Ed. H. Suzuki and F. Takai. Tokyo: Keigaku Publishing Co.

ENNOUCHI, E. (1962). Un Néandertalien: l'homme du Jebel Irhoud (Maroc). Anthropologie. Paris., 66: 279-299.

ENNOUCHI, E. (1963). Les Néanderthaliens du Jebel Irhoud (Maroc). C.r. hebd. Séanc. Acad. Sci., Paris. D., 256: 2459-2460.

ENNOUCHI, E. (1968). Le deuxième crâne de l'homme d'Irhoud. Annls. Paléont., 54: 117-128.

FARRAND, W.R. (1972). Geological correlation of pre-historic sites in the Levant. In: The origin of

Homo sapiens. Proceedings of the Paris symposium, September 1969, organised by Unesco in co-operation with the International Union for Quaternary Research (INQUA). Ed. F. Bordes. Paris: Unesco.

FEREMBACH, D. (1972). L'ancêtre de l'homme du Paléolithique supérieur était-il néandertalien? In: The origin of Homo sapiens. Proceedings of the Paris symposium, September 1969, organised by Unesco in co-operation with the International Union for Quaternary Research (INQUA). Ed. F. Bordes. Paris: Unesco.

FUHLROTT, J.C. (1857). Theilen des menschlichen skelettes im Neanderthal bei Hochdal. Verh. naturh. Ver. preuss. Rheinl., 14: 50

HEBERER, G. (1959). The descent of man and the present fossil record. Cold Spring Harb. Symp. quant. Biol., 24: 235-244.

HEMMER, H. (1972a). The evolutionary significance, taxonomy and environmental aspects of the Upper Pleistocene Neanderthal and neanderthaloid men of Europe, Asia and Africa. In: The origin of Homo sapien Proceedings of the Paris symposium, September 1969, organised by Unesco in co-operation with the International Union for Quaternary Research (INQUA). Ed. F. Bordes. Paris: Unesco.

HEMMER, H. (1972b). Notes sur la position phylétique de l'homme de Petralona. Anthropologie. Paris., 76: 155-161.

HIGGS, E.S. (1961). Some Pleistocene faunas of the Mediterranean coastal areas. Proc. prehist. Soc., 27: 144-154.

HOOTON, E.A. (1946). Up from the Ape. New York: Macmillan.

HOPE, K. (1968). Methods of multivariate analysis. University of London.

HOWELL, F.C. (1951). The place of Neanderthal man in human evolution. Am. J. phys. Anthrop., 9: 379-415.

HOWELL, F.C. (1952). Pleistocene glacial ecology and the evolution of "Classic Neandertal" man. S West. J. Anthrop., 8: 377-410.

HOWELL, F.C. (1957). The evolutionary significance of variation and varieties of "Neanderthal" man. Q. Rev. Biol., 32: 330-347.

HOWELL, F.C. (1960). European and Northwest African Middle Pleistocene hominids. Curr. Anthrop., 10: 475-503.

HOWELL, F.C. (1970). Early man. Time-Life.

HOWELLS, W.W. (1966). The Joman population of Japan. A study by discriminant analysis of Japanese and Ainu crania. Papers of the Peabody Museum, Harvard University, 57; 1-43.

HOWELLS, W.W. (1967). Mankind in the making. London: Penguin.

HOWELLS, W.W. (1969a). Criteria for selection of osteometric dimensions. Am. J. phys. Anthrop., 30: 451-458.

HOWELLS, W.W. (1969b). The use of multivariate techniques in the study of skeletal populations. Am. J. phys. Anthrop., 31: 311-314.

HOWELLS, W.W. (1969c). Comment on book review by D.S. Marshall. Hum. Biol., 42: 295-297.

HOWELLS, W.W. (1970a). Mount Carmel man: morphological relationships. In: Proceedings VIIIth International Congress of Anthropological and Ethnological Sciences, Tokyo and Kyoto, 1968. I. Anthropology: 269-272.

HOWELLS, W.W. (1970b). Multivariate analysis of human crania. In: Proceedings of the VIIIth International Congress of Anthropological and Ethnological Sciences, Tokyo and Kyoto, 1968. I. Anthropology: 1-3.

HOWELLS, W.W. (1973). Cranial variation in man: a study by multivariate analysis of patterns of difference among recent human populations. Papers of the Peabody Museum of Archaeology and Ethnology. 67.

HOWELLS, W.W. (unpublished). Neanderthal man: facts and figures. Paper prepared for the IXth International Congress of Anthropological and Ethnological Sciences, Chicago, U.S.A., September 1973.

HRDLIČKA, A. (1927). The Neanderthal phase of man. Jl. R. anthrop. Inst., 57: 249-274.

HRDLIČKA, A. (1930). The skeletal remains of early man. Smithson. misc. Collns., 83 (whole volume): 1-379.

JELÍNEK, J. (1969). Neanderthal man and Homo sapiens in Central and Eastern Europe. Curr. Anthrop., 10: 475-503.

KEITH, A. (1920). The antiquity of man. London: Williams and Norgate.

KEITH, A. (1931). New discoveries relating to the antiquity of man. London: Williams and Norgate.

KEITH, A. (1948). A new theory of human evolution. London: Watts.

KENDALL, M.G. (1958). A course in multivariate analysis. London: Griffin.

KLEIN, R.G. (1973). Geological antiquity of Rhodesian man. Nature, Lond., 244: 311-312.

KOENIGSWALD, G.H.R. von, (1967). Neue Dokumente zur menschlichen Stammesgeschichte. Eclog. geol. Helv., 60: 641-655.

KOWALSKI, C.J. (1972). A commentary on the use of multivariate statistical methods in anthropometric research. Am. J. phys. Anthrop., 36: 119-131.

KURTÉN, B. (1972). Urmänniskan från Petralona. Hufvudstadsbladet: March 12th 1972.

LEAKEY, L.S.B. (1935). Stone age races of Kenya. London: Oxford University Press.

LEAKEY, L.S.B. (1936). Fossil human remains from Kanam and Kanjera, Kenya Colony. Nature, Lond., 138: 643.

LEAKEY, L.S.B. (1953). Adam's ancestors. London: Methuen.

LEAKEY, L.S.B. (1972). Homo sapiens in the Middle Pleistocene and the evidence of Homo sapiens evolution In: The origin of Homo sapiens. Proceedings of the Paris symposium, September 1969, organised by Unesco in co-operation with the International Union for Quaternary Research (INQUA). Ed. F. Bordes. Paris: Unesco.

LEAKEY, L.S.B. & GOODALL, V.M. (1970). Unveiling Man's Origins. London: Methuen.

LEAKEY, R.E.F. (1973). Evidence for an Advanced Plio-Pleistocene Hominid from East Rudolf, Kenya. Nature, Lond., 242: 447-450.

LEAKEY, R.E.F., BUTZER, K.W. & DAY, M.H. (1969). Early Homo sapiens remains from the Omo River region of South-West Ethiopia. Nature, Lond., 22: 1132-1138.

de LUMLEY, H. and de LUMLEY, M.A. (1971). Découverte de restes humains anténéandertaliens datés du début du Riss a la Caune de l'Arago (Tautavel, Pyrénées-Orientales). C.r. hebd. Séanc. Acad. Sci., Paris. D. 272: 1739-1742.

MACINTOSH, N.W.G. (1952). The Cohuna cranium, history and commentary from November 1925 to November 1951. Mankind, 4: 307-329.

MAHANOLOBIS, P.C. (1936). On the generalised distance in statistics. Proc. natn. Inst. Sci. India., 12: 49-55.

MAHONY, D.J. (1943). The problem of the antiquity of man in Australia. Mem. Nat. Mus. Melbourne., 13.

MARSHALL, D.S. (1969). Book review of W.W. Howells and J.M. Crichton (1966) "Craniometry and multivariate analysis". Hum. Biol., 41: 290-295.

MAYR, E. (1950). Taxonomic categories in fossil hominids. Cold Spring Harb. Symp. quant. Biol., 15: 109-118.

MAYR, E. (1964). The taxonomic evaluation of fossil hominids. In: Classification and human evolution. Ed. S.L. Washburn. London: Methuen.

McBURNEY, C.B.M. (1972). Regional differences in the dating of the earliest leptolithic traditions. In: The origin of Homo sapiens. Proceedings of the Paris symposium, September 1969, organised by Unesco in co-operation with the International Union for Quaternary Research (INQUA). Ed. F. Bordes. Paris: Unesco.

McCOWN, T.D. & KEITH, A. (1939). The Stone Age of Mount Carmel, vol. 2: The fossil human remains from the Levalloiso-Mousterian. Oxford: Clarendon Press.

MELLARS, P.A. (prepublication draft 1971). The character of the Middle-Upper Palaeolithic transition in South-Western France. Paper presented to the research seminar on "The explanation of culture change: models in prehistory." Sheffield, 1971.

MONTAGU, M.F. ASHLEY (1947). Introduction to physical anthropology. Oxford: Blackwell.

MORANT, G.M. (1927). Studies of Palaeolithic man II. A biometric study of Neanderthaloid skulls and of their relationships to modern racial types. Ann. Eugen., 2: 318-380.

MORTON, D.J. (1926). Significant characteristics of the Neanderthal foot. Nat. Histo. N.Y., 26: 310-314.

MUSGRAVE, J.H. (1970). An anatomical study of the hands of Pleistocene and Recent Man; Thesis, Univ. of Cambridge.

MUSGRAVE, J.H. (1971). How dextrous was Neanderthal man? Nature, Lond., 233: 538-541.

MUSGRAVE, J.H. (1973). The phalanges of Neanderthal and Upper Palaeolithic hands. In: Human Evolution. Ed. M.H. Day. London: Taylor and Francis.

NESTURKH, M. (1967). The Origin of Man. Moscow: Progress Publishers.

OAKLEY, K.P. (1969). Frameworks for dating fossil man. London: Weidenfeld and Nicolson.

OAKLEY, K.P. & CAMPBELL, B.G. (eds.) (1967). Catalogue of fossil hominids. I. Africa. London: British Museum (Natural History).

OAKLEY, K.P., CAMPBELL, B.G. & MOLLESON, T.I. (eds.). (1971). Catalogue of fossil hominids. II. Europe. London: British Museum (Natural History).

OXNARD, C.E. (1972a). Some African fossil foot bones: a note on the interpolation of fossils into a matrix of extant species. Am.J. phys. Anthrop., 37: 3-12.

OXNARD, C.E. (1972b). Functional morphology in Primates: some mathematical and physical methods. In: The Functional and evolutionary biology of Primates. Ed. R.H. Tuttle. Chicago: Aldine-Atherton.

PATTE, E. (1955). Les Néanderthaliens: Anatomie, Physiologie, comparisons. Paris: Masson et Cie.

PEARSON, K. (1926). On the coefficient of racial likeness. Biometrika, 18: 105-117.

POIRIER, F.E. (1973). Fossil man: an evolutionary journey. Saint Louis: C.V. Mosby.

POULIANOS, A.N. (1967). The place of the Petralonian man among Palaeoanthropoi. Anthropos (Brno)., 19: 216-221.

POULIANOS, A.N. (1971). Petralona: a Middle Pleistocene cave in Greece. Archaeology., 24: 6-11.

POULIANOS, A.N. (1972). Some sapiens features of the Petralona skull (abstract). In: The origin of Homo sapiens. Proceedings of the Paris symposium, September 1969, organised by Unesco in co-operation with the International Union for Quaternary Research (INQUA). Ed. F. Bordes. Paris: Unesco.

RAO, C.R. (1952). Advanced statistical methods in biometric research. New York: John Wiley.

ROGUINSKY, Y. (1972). Sur l'ancêtre le plus proche de l'Homo sapiens et le lieu de sa transformation en homme moderne. In: The origin of Homo sapiens.

Proceedings of the Paris symposium, September 1969, organised by Unesco in co-operation with the International Union for Quaternary Research (INQUA). Ed. F. Bordes. Paris: Unesco.

SARTONO, S. (1971). Observations on a new skull of Pithecanthropus erectus (Pithecanthropus VIII) from Sangiran, Central Java. Proc. K. ned. Akad. Wet., Series B, 74: 185-194.

SEAL, H.M. (1964). Multivariate statistical analysis for biologists. London: Methuen.

SERGI, S. (1953). Morphological position of the "Prophaneranthropi" (Swanscombe and Fontéchevade). Reprinted in: Ideas on Human Evolution. Ed. W.W. Howells. 1962. Cambridge: Harvard University Press.

SERGI, S. (1958). The Neanderthal Palaeoanthropi in Italy. Reprinted in: Ideas on Human Evolution. Ed. W.W. Howells. 1962. Cambridge: Harvard University Press.

STEEGMAN, A.T. Jr. (1972). Cold response, body form, and craniofacial shape in two racial groups of Hawaii. Am. J. phys. Anthrop., 37: 193-222.

STEWART, T.D. (1959). The restored Shanidar I skull. Smithsonian Report for 1958: 473-480.

STEWART, T.D. (1960). Form of the pubic bone in Neanderthal man. Science, N.Y., 131: 1437-8.

STEWART, T.D. (1962a). Neanderthal cervical vertebrae, with special attention to the Shanidar Neanderthals

from Iraq. Biblthca. primatol., 1: 130-154.

STEWART, T.D. (1962b). Neanderthal scapulae with special attention to the Shanidar Neanderthals from Iraq. Anthropos. (St. Augustin). 57: 779-800.

STRAUS, W.L. & CAVE, A.J.E. (1957). Pathology and the posture of Neanderthal man. Q.Rev.Biol., 32: 323-329.

STRINGER, C.B. (1972). Cranial variation in Pleistocene hominids: preliminary results of statistical analyses. J.Anat., 114: 295.

STRINGER, C.B. A multivariate study of the Petralona skull. In the press.

STRINGER, C.B. (unpublished). A comparative study of Middle Pleistocene mandibles.

SUZUKI, H. (1970). The skull of the Amud man. In: The Amud man and his cave site. Eds. H. Suzuki and F. Takai. Tokyo: Keigaku Publishing Co.

SUZUKI, H. & TAKAI, F. (eds.) (1970). The Amud man and his cave site. Tokyo: Keigaku Publishing Co.

TAKAI, F. & CHINZEI, K. (1970). The Amud cave site and its deposits, and Fossil mammals from the Amud cave. In: The Amud man and his cave site. Eds. H. Suzuki and F. Takai. Tokyo: Keigaku Publishing Co

TALBOT, P.A. & MULHALL, H. (1962). The physical anthropology of Southern Nigeria. Cambridge.

THOMA, A. (1969). Biometrische studie über das occipitale von Vértesszőllős. Z.Morph.Anthrop., 60: 229-241.

THOMA, A. (1972). L'évolution polycentrique de l'Homo sapiens. In: The Origin of Homo sapiens. Proceedings of the Paris symposium, September 1969, organised by Unesco in co-operation with the International Union for Quaternary Research (INQUA). Ed. F. Bordes. Paris: Unesco.

THORNE, A.G. & MACUMBER, P.G. (1972). Discoveries of late Pleistocene man at Kow Swamp, Australia. Nature, Lond., 238: 316-319.

TRINKAUS, E. (1973). A reconsideration of the Fontéchevade fossils. Am. J. phys. Anthrop., 39: 25-35.

VALLOIS, H.V. (1949). The Fontéchevade fossil man. Am. J. phys. Anthrop., 7: 339-362.

VALLOIS, H.V. (1954). Neanderthals and praesapiens. Jl. R. anthrop. Inst., 84: 111-130.

VALLOIS, H.V. (1958). La grotte de Fontéchevade II. Archs. Inst. Paléont. hum., 29: 1-262.

VALLOIS, H.V. & MOVIUS, H.L. (1952). Catalogue des hommes fossiles. Proc. Int. Congr. Geologists, Algiers. 5.

VALLOIS, H.V. & VANDERMEERSCH (1972). Le crâne moustérien de Qafzeh (Homo VI): étude anthropologique. Anthropologie. Paris., 76: 71-96.

VAN VARK, G.N. (1970). Some statistical procedures for the investigation of prehistoric human skeletal material. Groningen: Rijksuniversiteit te Groningen.

VANDERMEERSCH, B. (1972). Récentes découvertes de squelettes humains à Qafzeh (Israël): essai d'interprétation. In: The origin of Homo sapiens. Proceedings of the Paris symposium, September 1969, organised by Unesco in co-operation with the International Union for Quaternary Research (INQUA). Ed. F. Bordes. Paris: Unesco.

WATANABE, H. (1970). Palaeolithic industry from the Amud cave. In: The Amud man and his cave site. Eds. H. Suzuki and F. Takai. Tokyo: Keigaku Publishing Co.

WATANABE, H. (1972). Periglacial ecology and the emergence of Homo sapiens. In: The origin of Homo sapiens. Proceedings of the Paris symposium, September 1969, organised by Unesco in co-operation with the International Union for Quaternary Research (INQUA). Ed. F. Bordes. Paris: Unesco.

WEIDENREICH, F. (1936). The mandibles of Sinanthropus pekinensis: a comparative study. Palaeont. sin. ser. D, 7, III: 1-163.

WEIDENREICH, F. (1937). The relation of Sinanthropus pekinensis to Pithecanthropus, Javanthropus and Rhodesian man. Jl.R. anthrop. Inst., 68: 51-65.

WEIDENREICH, F. (1940). Some problems dealing with ancient man. Am. Anthrop., 42: 375-383.

WEIDENREICH, F. (1943a). The skull of Sinanthropus pekinensis; a comparative study on a primitive hominid skull. Palaeont. sin. D, 10. whole volume 127: 1-484.

WEIDENREICH, F. (1943b). The "Neanderthal Man" and the ancestors of "Homo sapiens". Am. Anthrop., 42: 375-383.

WEIDENREICH, F. (1947). Facts and speculations concerning the origin of Homo sapiens. Am. Anthrop., 49: 187-203.

WEIDENREICH, F. (1949). Interpretations of the fossil material. Reprinted in: Ideas on Human Evolution. Ed. W.W. Howells. Cambridge: Harvard University Press.

WEIDENREICH, F. (1951). Morphology of Solo man. Anthrop. Pap. Am. Mus. nat. Hist., 43: 201-290.

WEINER, J.S. (1957). The evolutionary taxonomy of the Hominidae in the light of the Piltdown investigation. In: Sel. Papers Fifth Int. Congr. Anthrop. Ethnol. Sci.: 741-752.

WEINER, J.S. (1958). The pattern of evolutionary development of the genus Homo. Reprinted with modifications in: Ideas on Human Evolution. Ed. W.W. Howells. 1962. Cambridge: Harvard University Press.

WEINER, J.S., OAKLEY, K.P. & CLARK, W.E. Le Gros. (1953). The solution of the Piltdown problem. Bull. Br. Mus. nat. Hist. Geology, 2: 141-146.

WEINER, J.S. & CAMPBELL, B.G. (1964). The taxonomic status of the Swanscombe skull. In: The Swanscombe skull. A survey of research on a Pleistocene site. Ed. C.D. Ovey. London: Royal Anthropological Institute.

WELLS, L.H. (1951). The fossil human skull from Singa. In: Fossil mammals of Africa, No. 2. Eds. A.J. Arkell, D.M.A. Bate, L.H. Wells and A.D. Lacaille. London: British Museum (Natural History).

WOODWARD, A.S. (1938). A fossil skull of an ancestral Bushman from the Anglo-Egyptian Sudan. Antiquity, 12: 193-195.

APPENDIX (i)

Data sheets are appended of measurements taken on the following crania which have so far been little studied.

(a) Petralona

(b) Omo 1

(c) Omo 2

(d) Djebel Irhoud

(e) Cohuna

(f) Iwo Eleru

University of Bristol, England.

C. B. Stringer, Department of Anatomy, University of Bristol, England.

Date.....

CRANIAL AND MANDIBULAR MEASUREMENTS. Museum..Geological + Palaeontological Institute... Thessaloniki

Name of fossil.....PETRALONA.....Catalogue No.....

Cranium, ~~Mand. Calvaria, Calotte, Face, Maxilla, Cranial bones~~. Sex.....♂.....

Condition: Excellent, ~~Good, Fair, Poor~~.

BUT MATRIX ON FACE + BASE

1	glab-occ 1. GOL Ia	209	27	dac.sbt. DKS IIIc	10	53	EAM-zygorb. ZOR IIIb	86 ??
2	nas-occ 1. NOL Ia	200	28	intorb.br.DKB IIIc	[35]	54	EAM-frmlant.FMR IIIb	84
3	bas-nas 1. BNL Ia	110	29	nas-dac.st.NDS IIIc	[14]	55	EAM-ect.EKR IIIb	80 ?
4	bs-brg ht.BBH Ia	128	30	sim.chrd.WNB IIIc	–	56	EAM-zygmax.ZMR IIIb	(85)
5	max br. XCB Ia	156	31	sim.sbt. SIS IIIc	–	57	EAM-M¹alv. AVR IIIb	96
6	max fr.br. XFB Ia	120	32	mal.l.inf. IML IIb	[39]	71	EAM-breg.BRR IIIb	115
7	bisteph. br.STB IIb	113	33	mal.l.max.XML IIIa	56	72	EAM-lam.LAR IIIb	109
8	bizyg.br. ZYB IIb	163	34	mal.sbt. MLS IIIa	10	73	EAM-opis.OPR IIIb	47
9	biaur.br.AUB IIb	156	35	min.chk.ht.WMH IIb	34	74	EAM-bas. BAR IIIb	14
10	min.cr.br. WCB IIb	91	36	suporb.pr. SOS IIIa	13			

Mandibular Measurements

11	biast.br.ASB IIa	120	37	glab.pr. GLS IIId	12.5	75	bicond. br. W_1
12	bas-pros. BPL IIb	121	38	for.mag.1. FOL IIc	42	76	bigon. br. GoGo
13	nas-pros. NPH IIb	95	39	nas-br.cd.FRC IIIa	111	77	coronial.br. CrCr
14	nas.ht. NLH IIb	65	40	nas-br.sbt.FRS IIIa	21	78	bimental.br. ZZ
15	orb.ht.lft.OBH IIc	[35]	41	nas.sbt.fr.FRF IIIa	67	79	condyle. l. CyL
16	orb.br.lft. OBB IIc	(45)	42	br-lam.cd. PAC IIIa	111	80	proj.l.mand. ML
17	bijug.br.JUB IIb	141	43	br-lam.sbt.PAS IIIa	19	81	proj.l.corpus CpL
18	nas.br. NLB IIb	30	44	br.sbt.fr. PAF IIIa	60	82	min.ram.br. RB'
19	pal.br. MAB IIb	88	45	lam-opis.cd.OCC IIIa	93	83	mol.pm.cd. M_2P_1
20	mast.l. MDH IIb	[19]	46	lam-opis.sbt. OCS IIIa	42	84	symp.ht. H_1
21	mast.w. MDB IIb	[11]	47	lam-sbt fr. OCF IIIa	43	85	ectom.ht. M_2H
22	bimax.crd.ZMB IIIa	(110)	48	EAM-vert.VRR IIIb	117	86	cor.ht. CrH
23	zg.mx.st.SSS IIIa	(31)	49	EAM-nas NAR IIIb	103	87	prj.l.ramus RL
24	bifr.crd.FMB IIIa	126	50	EAM-subs.SSR IIIb	112	88	mand.angle ML
25	nas-fr.sbt.NAS IIIa	22	51	EAM-pros. PRR IIIb	120 ??	89	mental angle
26	biorb.br. EKB IIIc	124	52	EAM-dac. DKR IIIb	88 ??		

min frontal br = 110

bregma - asterion cd = 139 ??

C. B. Stringer, Department of Anatomy, University of Bristol, England.

Date.....

CRANIAL AND MANDIBULAR MEASUREMENTS. Museum...Geological + Palaeontological Institute Thessaloniki

Name of fossil.....PETRALONA.....Catalogue No.....

Cranium, ~~Mand. Calvaria, Calotte, Face, Maxilla, Cranial bones~~. Sex.....♂.....

Condition: Excellent, ~~Good, Fair, Poor~~.
BUT MATRIX ON FACE + BASE

1 glab-occ l. GOL Ia.....209.....27 dac.sbt. DKS IIIc.....10.....53 EAM-zygorb. ZOR IIIb..86??

2 nas-occ l. NOL Ia.....200.....28 intorb.br.DKB IIIc.....[35].....54 EAM-frmlant.FMR IIIb.....84.....

3 bas-nas l. BNL Ia.....110.....29 nas-dac.st.NDS IIIc.....[14].....55 EAM-ect.EKR IIIb.....80?.....

4 bs-brg ht.BBH Ia.....128.....30 sim.chrd.WNB IIIc.....-.....56 EAM-zygmax.ZMR IIIb.....(85).....

5 max br. XCB Ia.....156.....31 sim.sbt. SIS IIIc.....-.....57 EAM-M¹alv. AVR IIIb.....96.....

6 max fr.br. XFB Ia.....120.....32 mal.l.inf. IML IIb.....[39].....71 EAM-breg.BRR IIIb.....115.....

7 bisteph. br.STB IIb.....113.....33 mal.l.max.XML IIIa.....56.....72 EAM-lam.LAR IIIb.....109.....

8 bizyg.br. ZYB IIb.....163.....34 mal.sbt. MLS IIIa.....10.....73 EAM-opis.OPR IIIb.....47.....

9 biaur.br.AUB IIb.....156.....35 min.chk.ht.WMH IIb.....34.....74 EAM-bas. BAR IIIb.....14.....

10 min.cr.br. WCB IIb.....91.....36 suporb.pr. SOS IIIa.....13.....Mandibular Measurements

11 biast.br.ASB IIa.....120.....37 glab.pr. GLS IIId.....125.....75 bicond. br. W_1.....

12 bas-pros. BPL IIb.....121.....38 for.mag.l. FOL IIc.....42.....76 bigon. br. GoGo.....

13 nas-pros. NPH IIb.....95.....39 nas-br.cd.FRC IIIa.....111.....77 coronial.br. CrCr.....

14 nas.ht. NLH IIb.....65.....40 nas-br.sbt.FRS IIIa.....21.....78 bimental.br. ZZ.....

15 orb.ht.lft.OBH IIc.....(35).....41 nas.sbt.fr.FRF IIIa.....67.....79 condyle. l. CyL.....

16 orb.br.lft. OBB IIc.....(45).....42 br-lam.cd. PAC IIIa.....111.....80 proj.l.mand. ML.....

17 bijug.br.JUB IIb.....141.....43 br-lam.sbt.PAS IIIa.....19.....81 proj.l.corpus CpL.....

18 nas.br. NLB IIb.....30.....44 br.sbt.fr. PAF IIIa.....60.....82 min.ram.br. RB'.....

19 pal.br. MAB IIb.....88.....45 lam-opis.cd.OCC IIIa.....93.....83 mol.pm.cd. M_2P_1.....

20 mast.l. MDH IIb.....[19].....46 lam-opis.sbt. OCS IIIa.....42.....84 symp.ht. H_1.....

21 mast.w. MDB IIb.....[11].....47 lam-sbt fr. OCF IIIa.....43.....85 ectom.ht. M_2H.....

22 bimax.crd.ZMB IIIa...(110).....48 EAM-vert.VRR IIIb.....117.....86 cor.ht. CrH.....

23 zg.mx.st.SSS IIIa.....(31).....49 EAM-nas NAR IIIb.....103.....87 prj.l.ramus RL.....

24 bifr.crd.FMB IIIa.....126.....50 EAM-subs.SSR IIIb.....112.....88 mand.angle ML.....

25 nas-fr.sbt.NAS IIIa.....22.....51 EAM-pros. PRR IIIb.....120??.....89 mental angle.....

26 biorb.br. EKB IIIc.....124.....52 EAM-dac. DKR IIIb.....88??.....

min frontal br = 110

bregma - asterion cd = 139 ??

C. B. Stringer, Department of Anatomy, University of Bristol, England. Date 25/11/1971

CRANIAL AND MANDIBULAR MEASUREMENTS. Museum MIDDLESEX HOSPITAL

Name of fossil OMO 1 CAST Catalogue No.

~~Cranium, Mand.~~ RECONSTRUCTED Calvaria, ~~Calotte, Face, Maxilla, Cranial bones~~. Sex ♂

Condition: ~~Excellent~~, ~~Good~~, Fair, ~~Poor~~.

1 glab-occ l. GOL Ia 201 ??	27 dac.sbt. DKS IIIc –	53 EAM-zygorb. ZOR IIIb –	
2 nas-occ l. NOL Ia 195 ??	28 intorb.br.DKB IIIc –	54 EAM-frmlant.FMR IIIb –	
3 bas-nas l. BNL Ia –	29 nas-dac.st.NDS IIIc –	55 EAM-ect.EKR IIIb –	
4 ba-brg ht.BBH Ia –	30 sim.chrd.WNB IIIc –	56 EAM-zygmax.ZMR IIIb –	
5 max br. XCB Ia 152	31 sim.sbt. SIS IIIc –	57 EAM-M^1alv. AVR IIIb –	
6 max fr.br. XFB Ia –	32 mal.l.inf. IML IIb –	71 EAM-breg.BRR IIIb –	
7 bisteph. br.STB IIb [124]	33 mal.l.max.XML IIIa –	72 EAM-lam.LAR IIIb –	
8 bizyg.br. ZYB IIb –	34 mal.sbt. MLS IIIa –	73 EAM-opis.OPR IIIb –	
9 biaur.br.AUB IIb –	35 min.chk.ht.WMH IIb –	74 EAM-bas. BAR IIIb –	
10 min.cr.br. WCB IIb –	36 suporb.pr. SOS IIIa [10]	Mandibular Measurements	
11 biast.br.ASB IIa [115]	37 glab.pr. GLS IIId [5]	75 bicond. br. W_1	
12 bas-pros. BPL IIb –	38 for.mag.l. FOL IIc –	76 bigon. br. GoGo	
13 nas-pros. NPH IIb –	39 nas-br.cd.FRC IIIa [130]	77 coronial.br. CrCr	
14 nas.ht. NLH IIb –	40 nas-br.sbt.FRS IIIa [26]	78 bimental.br. ZZ	
15 orb.ht.lft.OBH IIc –	41 nas.sbt.fr.FRF IIIa [63]	79 condyle. l. CyL	
16 orb.br.lft. OBB IIc –	42 br-lam.cd. PAC IIIa [121]	80 proj.l.mand. ML	
17 bijug.br.JUB IIb –	43 br-lam.sbt.PAS IIIa [23]	81 proj.l.corpus CpL	
18 nas.br. NLB IIb –	44 br.sbt.fr. PAF IIIa [67.5]	82 min.ram.br. RB'	
19 pal.br. MAB IIb –	45 lam-opis.cd.OCC IIIa 99	83 mol.pm.cd. M_2P_1	
20 mast.l. MDH IIb 28.5 ??	46 lam-opis.sbt. OCS IIIa 30	84 symp.ht. H_1	
21 mast.w. MDB IIb 16.0 ??	47 lam-sbt fr. OCF IIIa 55	85 ectom.ht. M_2H	
22 bimax.crd.ZMB IIIa –	48 EAM-vert.VRR IIIb –	86 cor.ht. CrH	
23 zg.mx.st.SSS IIIa –	49 EAM-nas NAR IIIb –	87 prj.l.ramus RL	
24 bifr.crd.FMB IIIa [122]	50 EAM-subs.SSR IIIb –	88 mand.angle ML	
25 nas-fr.sbt.NAS IIIa [16]	51 EAM-pros. PRR IIIb –	89 mental angle	
26 biorb.br. EKB IIIc –	52 EAM-dac. DKR IIIb –		

min frontal br = [111]

bregma - asterion cd = [158 R]

C. B. Stringer, Department of Anatomy, University of Bristol, England. Date 25/11/1971

CRANIAL AND MANDIBULAR MEASUREMENTS. Museum MIDDLESEX HOSPITAL

Name of fossil OMO 2 CAST Catalogue No.....

~~Cranium, Mand~~. Calvaria, ~~Calotte, Face, Maxilla, Cranial bones~~. Sex ♂ ?

Condition: ~~Excellent~~, Good, ~~Fair, Poor~~.

1	glab-occ l. GOL Ia	213 ??	27	dac.sbt. DKS IIIc	–	53	EAM-zygorb. ZOR IIIb	–
2	nas-occ l. NOL Ia	–	28	intorb.br.DKB IIIc	–	54	EAM-frmlant.FMR IIIb	95 ??
3	bas-nas l. BNL Ia	–	29	nas-dac.st.NDS IIIc	–	55	EAM-ect.EKR IIIb	–
4	ba-brg ht.BBH Ia	–	30	sim.chrd.WNB IIIc	–	56	EAM-zygmax.ZMR IIIb	–
5	max br. XCB Ia	143	31	sim.sbt. SIS IIIc	–	57	EAM-M^1alv. AVR IIIb	–
6	max fr.br. XFB Ia	118.5	32	mal.l.inf. IML IIb	–	71	EAM-breg.BRR IIIb	126
7	bisteph. br.STB IIb	118.5	33	mal.l.max.XML IIIa	–	72	EAM-lam.LAR IIIb	115
8	bizyg.br. ZYB IIb	–	34	mal.sbt. MLS IIIa	–	73	EAM-opis.OPR IIIb	47
9	biaur.br.AUB IIb	131	35	min.chk.ht.WMH IIb	–	74	EAM-bas. BAR IIIb	–
10	min.cr.br. WCB IIb	[71]	36	suporb.pr. SOS IIIa	10		Mandibular Measurements	
11	biast.br.ASB IIa	126 ??	37	glab.pr. GLS IIId	5	75	bicond. br. W_1	
12	bas-pros. BPL IIb	–	38	for.mag.l. FOL IIc	–	76	bigon. br. GoGo	
13	nas-pros. NPH IIb	–	39	nas-br.cd.FRC IIIa	(118)	77	coronial.br. CrCr	
14	nas.ht. NLH IIb	–	40	nas-br.sbt.FRS IIIa	(19.5)	78	bimental.br. ZZ	
15	orb.ht.lft.OBH IIc	–	41	nas.sbt.fr.FRF IIIa	(58)	79	condyle. l. CyL	
16	orb.br.lft. OBB IIc	–	42	br-lam.cd. PAC IIIa	122 ??	80	proj.l.mand. ML	
17	bijug.br.JUB IIb	–	43	br-lam.sbt.PAS IIIa	17 ??	81	proj.l.corpus CpL	
18	nas.br. NLB IIb	–	44	br.sbt.fr. PAF IIIa	67 ??	82	min.ram.br. RB'	
19	pal.br. MAB IIb	–	45	lam-opis.cd.OCC IIIa	102 ??	83	mol.pm.cd. M_2P_1	
20	mast.l. MDH IIb	–	46	lam-opis.sbt. OCS IIIa	37 ??	84	symp.ht. H_1	
21	mast.w. MDB IIb	15	47	lam-sbt fr. OCF IIIa	42 ??	85	ectom.ht. M_2H	
22	bimax.crd.ZMB IIIa	–	48	EAM-vert.VRR IIIb	126.5	86	cor.ht. CrH	
23	zg.mx.st.SSS IIIa	–	49	EAM-nas NAR IIIb	–	87	prj.l.ramus RL	
24	bifr.crd.FMB IIIa	[108]	50	EAM-subs.SSR IIIb	–	88	mand.angle ML	
25	nas-fr.sbt.NAS IIIa	–	51	EAM-pros. PRR IIIb	–	89	mental angle	
26	biorb.br. EKB IIIc	–	52	EAM-dac. DKR IIIb	–			

minimum frontal br = 103 bregma-asterion cd = 150

C. B. Stringer, Department of Anatomy, University of Bristol, England. Date 26/10/1971

CRANIAL AND MANDIBULAR MEASUREMENTS. Museum Musée de l'Homme

Name of fossil DJEBEL IRHOUD 1 Catalogue No.

Cranium, ~~Mand. Calvaria, Calotte, Face, Maxilla, Cranial bones~~. Sex ♂ ?

Condition: Excellent, ~~Good, Fair, Poor~~.

1	glab-occ l. GOL Ia	197	27	dac.sbt. DKS IIIc	[6]	53	EAM-zygorb. ZOR IIIb	82
2	nas-occ l. NOL Ia	190	28	intorb.br.DKB IIIc	30 ??	54	EAM-frmlant.FMR IIIb	82
3	bas-nas l. BNL Ia	–	29	nas-dac.st.NDS IIIc	18 ??	55	EAM-ect.EKR IIIb	76
4	ba-brg ht.BBH Ia	–	30	sim.chrd.WNB IIIc	14 ??	56	EAM-zygmax.ZMR IIIb	75
5	max br. XCB Ia	150	31	sim.sbt. SIS IIIc	50 ??	57	EAM-M¹alv. AVR IIIb	91
6	max fr.br. XFB Ia	118 ??	32	mal.l.inf. IML IIb	–	71	EAM-breg.BRR IIIb	115
7	bisteph. br.STB IIb	113	33	mal.l.max.XML IIIa	–	72	EAM-lam.LAR IIIb	107
8	bizyg.br. ZYB IIb	155 ??	34	mal.sbt. MLS IIIa	–	73	EAM-opis.OPR IIIb	–
9	biaur.br.AUB IIb	140	35	min.chk.ht.WMH IIb	24	74	EAM-bas. BAR IIIb	–
10	min.cr.br. WCB IIb	[88]	36	suporb.pr. SOS IIIa	13	Mandibular Measurements		
11	biast.br.ASB IIa	120	37	glab.pr. GLS IIId	7	75	bicond. br. W_1	
12	bas-pros. BPL IIb		38	for.mag.l. FOL IIc	–	76	bigon. br. GoGo	
13	nas-pros. NPH IIb	75	39	nas-br.cd.FRC IIIa	108	77	coronial.br. CrCr	
14	nas.ht. NLH IIb	50	40	nas-br.sbt.FRS IIIa	23	78	bimental.br. ZZ	
15	orb.ht.lft.OBH IIc	37	41	nas.sbt.fr.FRF IIIa	57	79	condyle. l. CyL	
16	orb.br.lft. OBB IIc	43 ?	42	br-lam.cd. PAC IIIa	117	80	proj.l.mand. ML	
17	bijug.br.JUB IIb	130 ??	43	br-lam.sbt.PAS IIIa	15	81	proj.l.corpus CpL	
18	nas.br. NLB IIb	33	44	br.sbt.fr. PAF IIIa	55	82	min.ram.br. RB'	
19	pal.br. MAB IIb	75	45	lam-opis.cd.OCC IIIa	[89]	83	mol.pm.cd. M_2P_1	
20	mast.l. MDH IIb	16	46	lam-opis.sbt. OCS IIIa	[30]	84	symp.ht. H_1	
21	mast.w. MDB IIb	11	47	lam-sbt fr. OCF IIIa	[41.5]	85	ectom.ht. M_2H	
22	bimax.crd.ZMB IIIa	107 ??	48	EAM-vert.VRR IIIb	116	86	cor.ht. CrH	
23	zg.mx.st.SSS IIIa	29 ??	49	EAM-nas NAR IIIb	99	87	prj.l.ramus RL	
24	bifr.crd.FMB IIIa	117 ??	50	EAM-subs.SSR IIIb	104	88	mand.angle ML	
25	nas-fr.sbt.NAS IIIa	17 ??	51	EAM-pros. PRR IIIb	115	89	mental angle	
26	biorb.br. EKB IIIc	114	52	EAM-dac. DKR IIIb	82			

min frontal br = 106

bregma-asterion cd = 137

C. B. Stringer, Department of Anatomy, University of Bristol, England. Date 1/8/1971

CRANIAL AND MANDIBULAR MEASUREMENTS. Museum Morauske Museum Brno

Name of fossil COHUNA – Cast Catalogue No.....

Cranium, ~~Mand. Calvaria, Calotte, Face, Maxilla, Cranial bones~~. Sex ♂

Condition: ~~Excellent~~, Good, ~~Fair, Poor~~.

1	glab-occ l. GOL	Ia 200	27	dac.sbt. DKS	IIIc 13.5 ?	53	EAM-zygorb. ZOR IIIb 89
2	nas-occ l. NOL	Ia 194	28	intorb.br.DKB	IIIc 25.2 ?	54	EAM-frmlant.FMR IIIb 81
3	bas-nas l. BNL	Ia –	29	nas-dac.st.NDS	IIIc 11.2 ?	55	EAM-ect.EKR IIIb 76
4	bs-brg ht.BBH	Ia –	30	sim.chrd.WNB	IIIc –	56	EAM-zygmax.ZMR IIIb 82
5	max br. XCB	Ia 131	31	sim.sbt. SIS	IIIc –	57	EAM-M^1alv. AVR IIIb 97
6	max fr.br. XFB	Ia 105	32	mal.l.inf.^{R} IML	IIb 43.7	71	EAM-breg.BRR IIIb 125
7	bisteph. br.STB	IIb 98	33	mal.l.max.^{R}XML	IIIa 61.5	72	EAM-lam.LAR IIIb 14
8	bizyg.br. ZYB	IIb [142]	34	mal.sbt.^{R} MLS	IIIa 12	73	EAM-opis.OPR IIIb –
9	biaur.br.AUB	IIb 128	35	min.chk.ht.^{R}WMH	IIb 26.5	74	EAM-bas. BAR IIIb –
10	min.cr.br. WCB	IIb 72 ??	36	suporb.pr. SOS	IIIa 10		Mandibular Measurements
11	biast.br.ASB	IIa [110.7]	37	glab.pr. GLS	IIId 8	75	bicond. br. W_1
12	bas-pros. BPL	IIb –	38	for.mag.l. FOL	IIc –	76	bigon. br. GoGo
13	nas-pros. NPH	IIb 73.4	39	nas-br.cd.FRC	IIIa 125	77	coronial.br. CrCr
14	nas.ht. NLH	IIb 51.7	40	nas-br.sbt.FRS	IIIa 18	78	bimental.br. ZZ
15	orb.ht.~~left~~^{R}.OBH	IIc 28.7	41	nas.sbt.fr.FRF	IIIa 81	79	condyle. l. CyL
16	orb.br.~~left~~^{R}. OBB	IIc 42.6 ?	42	br-lam.cd. PAC	IIIa 117	80	proj.l.mand. ML
17	bijug.br.JUB	IIb 121.3	43	br-lam.sbt.PAS	IIIa 25	81	proj.l.corpus CpL
18	nas.br. NLB	IIb 30	44	br.sbt.fr. PAF	IIIa 54.5	82	min.ram.br. RB'
19	pal.br. MAB	IIb 73.7	45	lam-opis.cd.OCC	IIIa –	83	mol.pm.cd. M_2P_1
20	mast.l. MDH	IIb –	46	lam-opis.sbt. OCS	IIIa –	84	symp.ht. H_1
21	mast.w. MDB	IIb –	47	lam-sbt fr. OCF	IIIa –	85	ectom.ht. M_2H
22	bimax.crd.ZMB	IIIa 106	48	EAM-vert.VRR	IIIb 131	86	cor.ht. CrH
23	zg.mx.st.SSS	IIIa 25	49	EAM-nas NAR	IIIb 102	87	prj.l.ramus RL
24	bifr.crd.FMB	IIIa 108.5	50	EAM-subs.SSR	IIIb 107 ?	88	mand.angle ML
25	nas-fr.sbt.NAS	IIIa 21	51	EAM-pros. PRR	IIIb 120	89	mental angle
26	biorb.br. EKB	IIIc 109	52	EAM-dac. DKR	IIIb 90 ??		

min frontal br = 88

bregma-asterion cd = 136.5 ?

C. B. Stringer, Department of Anatomy, University of Bristol, England. Date 6/4/1972

CRANIAL AND MANDIBULAR MEASUREMENTS. Museum British Museum (Natural History).

Name of fossil IWO ELERU Catalogue No.....

~~Cranium, Mand~~. Calvaria, ~~Calotte, Face, Maxilla, Cranial bones~~. Sex ♂ ?

Condition: ~~Excellent, Good~~, Fair, ~~Poor~~.

1	glab-occ 1. GOL Ia	201	27	dac.sbt. DKS IIIc	–	53	EAM-zygorb. ZOR IIIb	–
2	nas-occ 1. NOL Ia	199	28	intorb.br.DKB IIIc	–	54	EAM-frmlant.FMR IIIb	98
3	bas-nas 1. BNL Ia	–	29	nas-dac.st.NDS IIIc	–	55	EAM-ect.EKR IIIb	–
4	bs-brg ht.BBH Ia	–	30	sim.chrd.WNB IIIc	–	56	EAM-zygmax.ZMR IIIb	–
5	max br. XCB Ia	148	31	sim.sbt. SIS IIIc	–	57	EAM-M^1alv. AVR IIIb	–
6	max fr.br. XFB Ia	(115)	32	mal.l.inf. IML IIb	–	71	EAM-breg.BRR IIIb	114
7	bisteph. br.STB IIb	(112)	33	mal.l.max.XML IIIa	–	72	EAM-lam.LAR IIIb	105
8	bizyg.br. ZYB IIb	–	34	mal.sbt. MLS IIIa	–	73	EAM-opis.OPR IIIb	42
9	biaur.br.AUB IIb	135	35	min.chk.ht.WMH IIb	–	74	EAM-bas. BAR IIIb	–
10	min.cr.br. WCB IIb	–	36	suporb.pr. SOS IIIa	7		Mandibular Measurements	
11	biast.br.ASB IIa	(116)	37	glab.pr. GLS IIId	5	75	bicond. br. W_1	
12	bas-pros. BPL IIb	–	38	for.mag.l. FOL IIc	–	76	bigon. br. GoGo	
13	nas-pros. NPH IIb	–	39	nas-br.cd.FRC IIIa	114	77	coronial.br. CrCr	
14	nas.ht. NLH IIb	–	40	nas-br.sbt.FRS IIIa	19	78	bimental.br. ZZ	
15	orb.ht.lft.OBH IIc	–	41	nas.sbt.fr.FRF IIIa	52	79	condyle. l. CyL	
16	orb.br.lft. OBB IIc	–	42	br-lam.cd. PAC IIIa	116	80	proj.l.mand. ML	
17	bijug.br.JUB IIb	–	43	br-lam.sbt.PAS IIIa	20	81	proj.l.corpus CpL	
18	nas.br. NLB IIb	–	44	br.sbt.fr. PAF IIIa	59	82	min.ram.br. RB'	
19	pal.br. MAB IIb	–	45	lam-opis.cd.OCC IIIa	(92)	83	mol.pm.cd. M_2P_1	
20	mast.l. MDH IIb	17	46	lam-opis.sbt. OCS IIIa	(31)	84	symp.ht. H_1	
21	mast.w. MDB IIb	14	47	lam-sbt fr. OCF IIIa	(41)	85	ectom.ht. M_2H	
22	bimax.crd.ZMB IIIa	–	48	EAM-vert.VRR IIIb	115	86	cor.ht. CrH	
23	zg.mx.st.SSS IIIa	–	49	EAM-nas NAR IIIb	112	87	prj.l.ramus RL	
24	bifr.crd.FMB IIIa	111	50	EAM-subs.SSR IIIb	–	88	mand.angle ML	
25	nas-fr.sbt.NAS IIIa	14	51	EAM-pros. PRR IIIb	–	89	mental angle	
26	biorb.br. EKB IIIc	114	52	EAM-dac. DKR IIIb	–			

min. frontal br = 97

bregma-asterion cd = 136

APPENDIX (ii)

The following papers or abstracts have been, or will be, published in connection with the work presented in this thesis, and two examples are provided here.

STRINGER, C.B. (1972). Cranial variation in Pleistocene hominids: preliminary results of statistical analyses. J. Anat., 114: 295

MUSGRAVE, J.H., STRINGER, C.B. & KOHLER, J.A. (1972). Demonstration: Craniometric studies of selected European Pleistocene and Recent populations. J.Anat., 114: 307

STRINGER, C.B. A multivariate study of the Petralona skull. In the press.

[*From the Proceedings of the Anatomical Society of Great Britain and Ireland, December* 1972. J. Anat., (1972), **114**, 2, p. 295]

9. Cranial variation in Pleistocene hominids: preliminary results of statistical analyses. By C. B. STRINGER (introduced by J. H. MUSGRAVE). *Department of Anatomy, University of Bristol.*

As part of a study of cranial variation in Pleistocene hominids, various craniometric measurements defined by Howells (*Multivariate Analysis of Human Crania*, unpublished) were taken on a number of fossil human skulls. The measurements were then subjected to univariate and multivariate analyses and in addition various cranial angles were computed.

The preliminary results confirm that the Neanderthals of Europe are a discrete group with several unique cranial characteristics, and suggest that modern *Homo sapiens* did not evolve from the 'classic' Neanderthals. Several problematical Middle and Upper Pleistocene crania were included in the study. Some of these, e.g. the Amud, Tabun and Saccopastore crania, appear to be closely related to the European Würm Neanderthals, whilst others such as the Skhul V and Omo 1 crania show affinities to the Upper Palaeolithic populations. The taxonomic position of yet other remains, among them those from Petralona, Steinheim, Solo and Djebel Irhoud, is less clear and demonstrates both the great variability and complex relationships to be considered in studies of Pleistocene hominids. Preliminary results also suggest that the Upper Palaeolithic populations of Europe and the Mesolithic populations of Europe and North Africa are not clearly demarcated from each other.

[*From the Proceedings of the Anatomical Society of Great Britain and Ireland, December* 1972. J. Anat., (1972), **114**, 2, p. 307]

D 4. Craniometric studies of selected European Pleistocene and Recent populations. By J. H. MUSGRAVE, C. B. STRINGER and JANICE A. KOHLER. *Department of Anatomy, University of Bristol.*

Cranial variation in several European populations is currently being studied in this Department. C. B. Stringer is trying to determine the phylogenetic relationship, as revealed in their cranial anatomy, between Neanderthal man and Upper Palaeolithic *Homo sapiens*. J. H. Musgrave is making a similar study on behalf of various British archaeologists of a series of Neolithic and Bronze Age skulls from Crete in an attempt to discover the origin of the Minoans. The craniometric techniques used are those devised by Professor W. W. Howells of Harvard University and involve taking 57 measurements and computing 13 angles on each complete skull. All the available metrical data are submitted to Canonical Variates Analyses and Mahalanobis' D^2 Tests with programs written by Dr M. R. B. Clarke of the London University Institute of Computer Science. To enhance the objectivity of these analyses Professor Howells has also generously provided data on 1653 complete crania representing 17 groups of living and prehistoric *Homo sapiens*. The major items displayed will be: the instruments employed; flow diagrams of our methods; casts and photographs of our material, including unpublished stereophotographs of Neanderthal crania; and the latest results of the statistical analyses.

Short names for angles and variables used in alphabetical order

ASB = biasterionic breadth
AUB = biauricular breadth
AVR = M1 alveolus radius
BAA = basion angle, NA-PR
BAC = bregma-asterion chord
BRA = bregma angle NA-BA
EKB = biorbital breadth
EKR = ectoconchion radius
FMB = bifrontal chord
FMR = frontomalare radius
FRC = nasion-bregma chord
FRF = nasion-subtense fraction
FRS = nasion-bregma subtense
GLS = glabella projection
GOL = glabello-occipital length
JUB = bijugal breadth
MAB = palate breadth
MDB = mastoid width
MDH = mastoid length
NAA = nasion angle, BA-PR
NAR = nasion radius
NAS = nasio-frontal subtense
NBA = nasion angle, BA-BR
NFA = nasio-frontal angle
NLB = nasal breadth
NLH = nasal height
NOL = nasio-occipital length
NPH = nasion-prosthion length
OBB = orbit breadth left
OBH = orbit height left
OCC = lambda-opisthion chord
OCF = lambda-subtense fraction
OCS = lambda-opisthion subtense
PAC = bregma-lambda chord
PAF = bregma-subtense fraction
PAS = bregma-lambda subtense
PRA = prosthion angle, NA-BA
PRR = prosthion radius
SOS = supraorbital projection
SSR = subspinale radius
STB = bistephanic breadth
VRR = vertex radius
WMH = cheek height
XCB = maximum cranial breadth
XFB = maximum frontal breadth
ZMA = zygomaxillare angle
ZMB = bimaxillary chord
ZMR = zygomaxillare radius
ZOR = zygoorbitale radius
ZYB = bizygomatic breadth